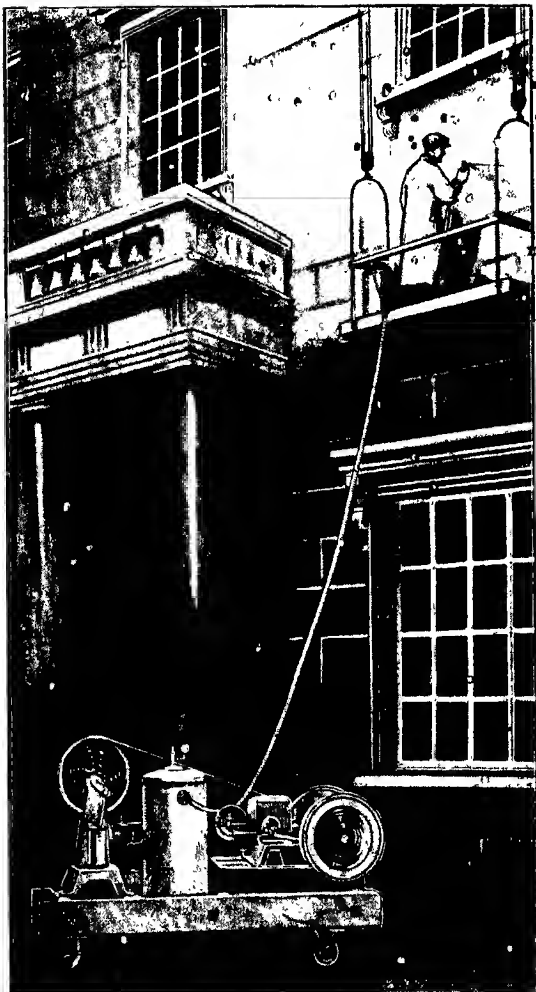
PAINTS AND VARNISHES



PAINTING THE FRONT OF A HOUSE BY SPRAYING WITH THE "AEROGRAPH" PORTABLE APPARATUS

Frontispiece

PITMAN'S COMMON COMMODITIES AND INDUSTRIES

PAINTS AND VARNISHES

WITH SPECIAL REFERENCE TO THEIR PROPERTIES AND USES

BY

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PREFACE

PAINTS and varnishes are essential in very many industries—certainly over one hundred—in addition to house painting, the needs of which probably account for less than ten per cent. of the total product.

A comprehensive description of the whole subject would necessitate a much larger volume than this, but I have endeavoured to deal with the most important facts which are of interest from a purely commercial and professional point of view.

Thus the essential properties of paints which determine their quality, the quantity required to cover given surfaces and the determination of probable durability, are dealt with at some length. The process of manufacture is only described when it becomes necessary in order to differentiate between grades or qualities of the same material.

It is hoped that this little book will prove of service to the property owner, the architect, and the painter, besides those who seek a knowledge of a class of commodities the importance of which is not so fully recognized as it might be.

ARTHUR S. JENNINGS.

26 INVERNESS TERRACE,
BAYSWATER, W.
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CHAPTER I

THE CHARACTERISTICS OF A GOOD PAINT

DEFINITION OF PAINT.—Oil paint may be defined as a mixture of pigment such as ochre, iron oxide, white lead or zinc oxide, with a drying oil such as linseed oil, the mixture being thinned with turpentine in order to produce a semi-liquid which may be applied to a surface with the object of preserving or beautifying it or both. Colour is often added and frequently "driers" also to facilitate the paint "drying." The drying is effected by the absorption of oxygen from the air hence the free admission of fresh air to a freshly-painted room is essential.

Webster's International Dictionary, 1919, defines paint thus—

"A preparation of pigments or colouring substances, made by mixing with some suitable vehicle, as oil, water or varnish, and forming when applied to a surface, an adhesive coating."

In *Newnes' Technological and Scientific Dictionary*, paint is thus described—

"A liquid or semi-liquid consisting of one or more pigments reduced to a fine powder and mixed with linseed oil and turpentine or other vehicles, and intended to be used for the preservation or beautifying of the surface to which it is applied."

This subject of a definition of paint was discussed,

1—(1467D)

some years since, at a meeting of the Paint and Varnish Society. The opener of the discussion, after finding fault with all the definitions contained in the various dictionaries, suggested the following—

"Paint is a self-hardening, adhesive mixture, consisting of particles of solid matter, suspended in liquid, which will fulfil the function of beautifying or protecting the surface to which it is properly applied."

This definition received the approval of the majority of the members, although a close examination would show that it also might be adversely criticized. It is not advisable to state that paint must contain oil, because we have water paints, spirit paints, tar paints, celluloid paints, glue paints, cement paints and many others, which do not contain a drop of oil. However, for our present purpose the definitions quoted will serve, as most people have a distinct idea of what paint is and what purpose it serves, although they are not aware of the extent to which it is used, or the very large variations which may take place in its constituents.

The pigments used in making paints are very many in number and may be classified under the heads of (*a*) natural, (*b*) chemical, (*c*) sublimed.

In addition to the above there are water paints and varnish paints, each of which is mixed with the substance included in the name.

Among painters and paint manufacturers the word "paint" refers to a stiff paste formed of a pigment ground in linseed or a similar oil. Thus the words "white lead," "ochre," and "zinc oxide" would be taken to refer to the dry powder in each case, and if oil were added the word "paint" would describe the condition, *e.g.*, "white lead paint," etc. If a sufficient quantity of oil driers and turpentine were added by the manufacturers to render the mixture ready for

application it would be termed "ready-mixed" or "ready-prepared paint." The pure pigment if ground in oil would be so described, *e.g.*, "genuine white lead in oil."

And here is reached a point of considerable commercial importance and one which should never be overlooked in buying and selling. It is that the custom of the trade justifies the addition of other materials than the one named in the title. Thus "white lead paint" might properly be applied to a mixture of, say, 10 per cent. of white lead and 90 per cent. of other pigments when ground in oil. In America it has been decided in a court of law that in such a case the mixture must contain at least more than 50 per cent. of the pigment named to justify the title, but in Great Britain no decision has been taken as far as the author is aware, and the proportion of the main pigment actually present will depend upon the price at which the mixture is sold or the fancy of the manufacturer.

The equivalent for "pure" in the paint trade is "genuine"; hence "genuine white lead ground in genuine (or pure) linseed oil" means exactly what is stated and indicates the commercial purity of all painters' materials to which it is applied. It can be so employed in the case of white lead, zinc oxide, linseed and other drying oils, turpentine and many other materials, but it cannot be applied to many others such as Brunswick green, the lakes, etc., as the constituents and their proportion vary and there can hardly be said to be a standard. The same is true to a considerable extent with earth colours such as natural iron oxides, siennas, ochres, etc., the analysis of which varies largely and gives but little information as to the actual value of the pigment from a paint-maker's point of view. At the same time the presence of a material which could

not possibly form part of the genuine article must be regarded as an adulteration, as, for example, in the case of an ochre which is often "doctored" or "improved" by the addition of a little chrome yellow put in to give a brighter colour or tone. As chrome yellow is never found in natural ochre the addition is clearly an adulteration, and it is no justification to assert that its addition is an actual improvement. If the ochre were naturally of the bright colour possessed by the mixture, it would retain that colour permanently, but as the chrome yellow embraces a lead compound in its composition it would be affected by impure air and sulphuretted hydrogen, etc., which would darken it.

It will be understood from the above that if the word "genuine" is used as an adjective in the description of a pigment, it is intended to convey the fact that the material is commercially pure. It will also be clear that if the same pigment is ground in oil it can still be properly described as "genuine," as, for instance, "genuine white lead ground in pure linseed oil." To reiterate, if the word "paint" is added, there is no implied guarantee as to purity, and the paint may contain any pigment provided that at least some proportion of the one described in the description is present.

A few words of explanation may be here given as to the meaning of the phrase "commercially pure." It really means nearly pure or substantially pure, while absolute purity would be covered by the expression "chemically pure." For example, zinc oxide on analysis might be found to contain 0·5 per cent. of white lead or other substance, and would be counted commercially pure. Such a sample, however, would not answer for pharmaceutical purposes and could not be described as chemically pure.

THE ESSENTIAL PROPERTIES OF A GOOD PAINT.—Although it is not easy accurately to determine the quality of paint by merely examining it, there are certain well-defined indications which will materially assist to that end. The principal of these are (*a*) colour, (*b*) elasticity, (*c*) body, (*d*) spreading quality, (*e*) fineness of the particles or freedom from grit.

Colour.—The distinguishing colour, tint, tone or hue is of considerable importance. Thus, an ochre may be so deficient in yellow or red hue as to be ineligible for classification as an ochre at all, being better described as a fine clay. A white lead may be "off-colour" to an extent that gives a yellowish hue, and some batches which are defective in this respect are condemned for use as paints but are utilized for glass-making. The blues, greens, red, etc., all have their distinctive characteristics which can only be successfully judged by comparison with a similar colour of well-known excellence.

And here it is well to remark that in nearly all paint tests it is desirable to select a standard of a similar material with which to make comparisons whether they be of colour, fineness, body, or any other quality. If the standards are carefully chosen the comparison will be exceedingly helpful. Of course, it may happen that the paint under test proves superior to the test which will distinguish it as being of superior character. Then the cost price must be taken into consideration, because if a paint costs, say, only one-half of that of another with which it is compared—to take an extreme case—and comes within measurable distance of the same general quality it may be really much cheaper.

As a general rule, however, the most expensive paint is the cheapest in the end, because of the cost of labour necessary in its application which may usually be taken

at about twice that of the paint itself. If, for instance, it costs, say, £20 for the quantity of paint sufficient to finish a building one coat, and £40 to apply it, and the particular paint lasts only three years, the total cost will be £60 each time the building is re-painted or an average of £20 a year. But if a paint is used of a greatly improved quality, and it costs £40, or twice as much, plus £40 for the application (this cost being exactly the same whether the paint is good or bad), and it lasts ten years, the total cost will be £80, or only £8 a year. These facts I have explained at length in my book, *Commercial Paints and Painting* (A. Constable & Co.).

Elasticity.—This property is most important, particularly in outside painting, and will depend upon the nature and quality of the vehicle (oil or oil and varnish) used in mixing. The action of the weather with the alternate heat and cold renders a certain amount of elasticity quite necessary, because the paint film expands and contracts with the variations of the temperature. A simple but practical manner of testing the elasticity of a paint, enamel or varnish is to apply it to a piece of thin iron and when dry to bend the iron double. There is, however, some difficulty in getting the paint to adhere to the iron, but even if it comes off from the surface the film can be bended. If the paint chips in places it indicates non-elasticity. Enamels will not break when of good quality if even the iron is bent double.

A better test is to scratch the surface of the paint when hard with a sharp point, and to denote the nature of the scratch very carefully using a strong reading-glass for the purpose. If the paint is brittle the scratch will show a broken, ragged or serrated edge, but if it is elastic the scratch will be clean cut and sharp at the edges. This test is an excellent one to apply to linseed

and other oils before being mixed with pigment. It is of importance to note that in practice it is undesirable to use too much oil and so obtain increased elasticity, first, because the surface so obtained will be difficult to repaint, and secondly, because, beyond a certain limit, the paint will be weakened. A film of linseed oil without pigment is not at all durable.

Body.—This is one of the most important qualities of a paint and actually means its opacity—in other words, the quality of hiding the surface to which it is applied. White lead ground in oil has excellent body, lithopone even more, zinc oxide a little less than lead. Some pigments have good body in one vehicle and only poor body in another, as, for example, whiting which shows up splendidly when mixed with water forming distemper, but very badly indeed if mixed with oil. Whiting is therefore never used as an oil paint.

Now it is evident that one of the objects of applying paint is to hide the surface, as, for instance, in wood, the knots and grain. It is equally evident that the better the body the paint possesses the fewer will be the number of coats required, or to put it in another way, if a paint is somewhat deficient in body an extra coat will be required for finishing an ordinary job with a corresponding increase in the cost. For this reason it is often necessary to ascertain what body a paint actually possesses. For example, if a new brand of ready-mixed paint is to be examined, one of the first things to be done is to ascertain its body when compared with, say white lead.

The following method is not very exact or scientific, but it will be found sufficiently useful for ordinary purposes. Prepare two painted white boards with broad, black stripes across them. Both the black and white paint should be free from gloss. Now take exactly

the same quantity by weight of each paint, *i.e.*, the white lead and the one which is to be compared with it, and paint out as far as it will go over the several boards taking care to mark each board so that the two may not be confused. Use separate clean brushes for each specimen. The one which best hides the black stripes has the greater body.

Provided that the boards are sufficiently large and the quantity of paint small, this test also demonstrates the second important quality, viz., its *spreading capacity*, or the surface which a given quantity will cover or spread over. The importance of this quality can hardly be over-estimated, because the actual coat of a job of painting will depend upon it. Zinc oxide and lithopone spread over at least 25 and often up to 33 per cent., a greater surface than white lead does when all of the three are mixed to a proper working consistency to be applied by a brush.

In view of the foregoing it will be clear that the spreading capacity and the body should be tested together, because it will be obvious that the thinner the paint is made by the addition of a greater amount of oil the farther it will spread, but at the sacrifice of body. And it is in this respect that the test is, as has been said, unscientific. Opinions may vary as to what is "a proper working consistency." If too much oil is added the body will suffer in consequence.

In practice the best way is to get the actual mixing of the paints done by an experienced house painter *without letting him know which is which*, so that he cannot possibly have a bias in favour of either one or the other.

In place of the painted boards sheets of glass may be used each of which has pasted on it any printed matter in large type. The black letters show through the glass and take the place of the black painted stripes.

The fact, too, that the glass is non-absorbent is an advantage in making this test. It may be mentioned that certain colours such as sienna and the lakes do not possess much body, being used principally for "glazing" or to give brilliancy to more sombre colours which possess the requisite body. Thus, Indian red glazed with carmine or crimson lake produces a very handsome effect.

Notwithstanding the above remarks concerning the importance, in most cases, of a paint possessing good body, it must be observed that painters, in their anxiety to get the work covered with as few coats as possible, sometimes mix their paint far too thick. Now it is the oil which, in conjunction with the pigment, gives a film which resists the action of the weather, and if there is insufficient oil the durability is correspondingly reduced particularly on outside work. Four thin coats properly mixed will last much longer than three thick coats, and three thin coats longer than two thick ones. As a rule, four coats will be required for new work and two or three for old work.

A curious property of zinc oxide paint may be noted here. As this pigment necessitates the use of a considerable amount of oil in grinding, it naturally covers, weight for weight, a larger surface than other pigments, such as white lead, for example. A single coat for this reason has less body than the lead; the second coat is about equal, while the third coat is distinctly better. These observations were made by Mr. J. Cruickshank Smith, B.Sc., F.C.S., as the result of some careful experiments.

Fineness.—It has been asserted with a good deal of truth that, other things being equal, the finer a pigment is the more durable a paint it makes. Lamp black, sublimed lead and zinc oxide may be given as

examples of pigments of which the particles are very fine and they all make durable paints. Earth colours, such as ochres, are of very little use unless they are finely ground; indeed, all grainers' colours, siennas, ochres, umbers and Vandyke brown, should be almost as fine as butter when ground in oil in order to get the best results.

It is frequently desirable to test a pigment for fineness and the process is quite simple. If it is ground in oil, such oil must be first extracted by a process which will be presently explained, but before doing this a very little may be rubbed between the tongue and the teeth and also between the thumb-nails when any grittiness will be easily detected. A little of the dry pigment mixed with water may be tried with a spatula or artists' knife on a sheet of plate glass when grit will be readily discerned. Still another way is to thin out the paint with turpentine, paint it on a sheet of plate glass side by side with another sample of which the fineness is known to be good. A comparison between the two will indicate which is the finer.

But perhaps the best test is to take a standard pigment and test it against the sample in the following manner. Take two clear glass bottles and fill with water. Introduce an equal quantity of the pigments one in each bottle and shake vigorously. Then note the time it takes each to settle. The one which takes the longer is the finer pigment. Of course, the two samples to be compared must be similar, *e.g.*, white lead must be compared with white lead, zinc oxide with zinc oxide, and so on.

One more test for white pigments may be mentioned because it is, perhaps, the most frequently used. It is to weigh out very carefully exactly equal quantities of the two white pigments to be compared. Then add to

each an equal quantity of a tinting colour. Thoroughly mix and compare. The lighter of the two samples will indicate the finer ground pigment because the finer the pigments are the greater will be the surface to be coloured.

To Extract Oil from a Paint.—In testing the fineness of pigments as well as the tinting strength of colours and in various other tests with paint, it is often necessary to extract the oil. To do this first place a little of the paint on stout blotting paper which will, in the course of a few minutes, absorb a good deal of the oil. Then take a bottle, warm it at the fire, put in it the paint and fill up with benzol or petrol. Shake the bottle and allow it to rest. After a little time the oil will float at the top and the pigment will settle to the bottom. Pour off the oil very carefully and repeat the operation two or three times if necessary, until no more oil is seen floating on the surface. Then carefully pour off the liquid (benzol, etc.), and place the moist pigment on blotting paper. In ten minutes or so the liquid will evaporate leaving the dry pigment ready for experimental purposes. It need hardly be said that this test must not be carried out in the presence of a naked light, because of the risk of the benzol or petrol catching fire.

The Mixture of Pigments in a Paint.—It is only in recent years that it has been clearly proved that a more durable paint may be produced by an admixture of pigments than one made of a single pigment, and this is particularly true with the various whites.

Almost invariably, in Great Britain at least, genuine white lead is specified as the principal ingredients of white or light paints—indeed, many architects and others seem to act upon the assumption that the durability of a paint is in proportion to the quantity of pure white lead it contains.

This is, however, quite a mistake, because although white lead forms an excellent paint for many purposes there are other pigments which prove equally or more durable if properly mixed.

The question now to be determined is whether a pure white lead paint can be improved by the addition of any other pigment, and the author is very positive in his emphatic assertion that it can. For many years he has experimented with various mixtures, and his researches have been amply verified by the large number of service tests made in America which are referred to in another chapter. A carefully compiled synopsis of these tests and of the results obtained by the exposure of paints of various kinds are given in *Paint Researches and their Practical Application*, by Henry A. Gardner. They were made on a scientific basis and at the same time a practical one, and a careful study of the results obtained will show that by a judicious admixture the shortcomings of one pigment—and no pigment can be justly considered as ideal or perfect—may be made up by the addition of the proper proportion of another which is strong in that particular quality where the other is comparatively weak.

A single instance will render this point quite clear. The properties of white lead and zinc oxide are given elsewhere in this book under their respective heads. There it is shown that white lead when mixed as a paint is relatively soft and apt to turn "chalky,"—a painter's expression meaning that after some months' exposure, particularly at the seaside, the paint loses some of its properties of adhesion and will be found to come off like badly-bound whitewash when the glove or —preferable for this test—a piece of dark cloth is rubbed against its surface upon which it leaves a light mark. This, it will be observed, means that the paint film is

perishing, and the action of rain, etc., will cause the paint to be ultimately washed off.

On the other hand, zinc oxide, to take a convenient example, dries comparatively hard and brittle, and hence a mixture of the two in the proportion of, say two-thirds of white lead and one-third of zinc oxide, yields a much more durable paint than either pigment when used alone because, as stated, the defects of one are corrected by the strength of the other. The lead, too, possesses a better "body" than the zinc, but the addition of 33 per cent. is insufficient to seriously reduce this important quality. Other pigments besides colour may also be added in equal proportions with advantage, as will be presently explained.

DESIGNING PAINTS.—If the untenable theory of the use of a single pigment in a paint is abandoned it will be seen that the particular mixture of pigments may be varied according to the nature of the surface to which the paint is to be applied, and this is true also to a certain extent as far as the thinners are concerned.

Modern practice demands the designing of a paint in order that it shall best fulfil its functions, and the mixture which proves most satisfactory for one position may be almost the worst for another. An example is afforded in comparing iron and plaster. The former, being non-absorbent, needs but little thinners, while the latter, being very absorbent, needs a good deal. Wood may be said to come between the two, and even here the thinners will require variation, because the porosity of different woods which may be classified as "hard," "medium," and "soft," varies greatly.

The position a painted surface is to occupy will in like manner determine its composition. For example, a paint which is to be used in smoky atmospheres containing sulphur compounds or one which contains

ammonia and sulphurous fumes such as stables, laboratories, etc., should be free from lead altogether, because such agents will inevitably cause discoloration. Zinc oxide or some similar pigment which will remain unaffected must be used. Again, an iron bridge requires a different paint to a piece of standing machinery, a railway carriage must be painted in a special manner to withstand the severe wearing action both of weather and cinders, dust, etc. A further example is the paint used on board merchant ships where frequent renewals are necessary and where the labour is almost always available. In such cases cheap paints may be used with advantage and sometimes they are renewed during almost every voyage.

READY-PREPARED PAINTS.—It is for the reasons given that the very best grades of paints which are sent out in a condition ready for use are almost always made from an admixture of pigments, and it must be remembered that in the preparation of such paints the object is to produce the best paint it is possible to manufacture regardless within reasonable limits of cost.

The objection raised to ready-mixed paints of even the highest grades may be summarized under three heads: (1) that the painter or user has no guarantee as to the constituents of such paints, but he has such guarantee when he buys genuine white lead, zinc oxide, etc.; (2) that as the particular brand of ready-prepared paint must be of a constant mixing as regards proportion of "thinners," *i.e.*, oil and turpentine it contains, it is suitable only for surfaces which may be termed normal or ordinary and is unsuitable for those surfaces which are either unusually absorbent or the reverse; (3) that it is peculiarly the painter's office to determine the condition of a surface which is to be painted and in

the light of his experience to decide as to the quantity of thinners which are necessary. (4) As the province of the painter is to mix his paint suitable for the particular job in hand, and as ready-prepared paints may possibly be applied by the unskilled, it is against the dignity of a professional painter to use such paints, and is likely to be taken as an indication that he does not understand his business.

Taking these objections in order. As to the first, it is suggested that it is as a matter of fact unimportant that the painter should know the exact constituents of the paint he uses. What he is deeply interested in is the results which may be obtained by using them; in other words, their appearance when first applied and how long they will remain without deterioration. A patient does not as a rule ask his medical man to state the drugs he is administering, he is satisfied if they produce the results aimed at and effect a cure.

Assuming, however, that the reader is quite convinced that an admixture of pigments gives better results than a single pigment used alone he can, if he so desires, order batches of paint ground to a stiff paste and ready for thinning down in the usual manner which shall consist of two-thirds of white lead and one-third of zinc oxide or any other proportion he desires.

The writer is very certain that if paint manufacturers would send out such mixtures in stiff paste form labelled to show the exact proportion of the different pigments contained they would have a large sale. At the present time the paint user who is fully convinced of the value of an admixture of pigments is forced to buy ready-prepared paints which he so often objects to, or to have the mixture specially made for his requirements, and this in the case of small quantities is impracticable.

It is true that he can purchase both the lead and the zinc separately and mix them to suit his taste, but a mere mixing does not give the same results as when the two pigments are ground together in the latest improved mills.

The reason which has probably stood in the way of combination paints in stiff paste form being placed on the market is that white lead in Great Britain is corroded as a separate business from the manufacture of paint in general, and also—and this fact has a most important bearing on the subject—zinc oxide is made to only a very limited extent in England and supplies are almost wholly imported from the Continent and the United States of America. Excepting in the case of two firms, one at Glasgow and one at Bristol, all white lead produced in Great Britain is corroded as a separate business to that of paint manufacture. Such corroders make also sheet lead, lead pipes, etc., and various lead compounds, such as red lead, orange lead, litharge, etc., and sell white lead in a dry state to the paint grinders, paint makers and colour grinders who grind it in oil and sell it in stiff paste form or as a constituent of their mixed paints. This being the case, it will be observed that there is but little encouragement for the lead corroder who has to purchase his zinc oxide to put a combination paint on the market, as suggested, but there is this very important fact to be remembered in this connection, and that is, that in the future zinc oxide is certain to be made on an extensive scale in England, and it is not improbable that lead corroders will put down plants for the purpose. A regular supply of zinc ore in great quantities having been assured from Australia and elsewhere, and the demand for zinc oxide having largely increased, the production of home-made zinc oxide on an extensive scale is inevitable.

Combination paints ready to be mixed by the painter will then come as a natural sequence.[1]

Returning to a consideration of the second objection advanced to the use of prepared paints as stated above, it is true that the amount of thinners used in such a paint as sent out from the factory must be constant, but the practical man, in the case of the priming coat, can easily take away some of the thinners by pouring them off before the mixture is stirred up and can therefore meet the conditions when they require but little oil and turpentine. If the surface is more absorbent than wanted and requires more thinners, these can very easily be added, so that this objection is knocked on the head.

As to the fourth objection advanced under No. 4 above, it need only be said that even the highest class painters and decorators use enamels to a very considerable extent and these are nothing more or less than ready-prepared paints. Fifty years ago it was the practice to prepare white enamelled work by giving ten or more coats of zinc oxide carefully rubbing down each coat and finishing with one or more coats of pale varnish. To-day the same result is obtained with three or four coats by using white enamel, and no one thinks that the decorator is deficient in knowledge because he uses them.

Some thirty years ago in the United States of America

[1] Since the above paragraphs were written two important departures have been made in the direction indicated. Zinc oxide is now made in considerable quantities in Great Britain. There has also been marketed semi-paste paint, *i.e.*, a paint much thinner than the usual paste and this only requires the addition of more oil and turpentine—more or less according to how absorbent the surface is to which it is to be applied—to render it ready for use. Both genuine white lead and lead and zinc mixed are now supplied in this form by at least two firms, and it is very probable that others will follow suit before long.

there existed the same objection to the use of ready-prepared paints as that which exists in England to-day and on much the same grounds. But now, in America, the consumption of mixed paints has reached enormous figures, and decorators of all classes use them freely and quite openly.

The fact is, that such paints if carefully made of properly-selected materials give better value than if those materials are mixed by hand, and this is only another example of the advantages of machinery. It must stand to reason that a fully-equipped mixing and grinding machine can produce a better paint than one mixed by hand. The whole thing, therefore, turns to the selection of the particular brand which indicates high quality, and this can only come from experience. The writer could name at least a dozen brands of such paints which may always be relied upon, and the strongest efforts of some of the largest paint manufacturing houses should be directed towards creating for their particular brand a guarantee of excellence equal to that of, say, Martell's Three Star Brandy, or a Corona-Corona cigar.

Inferior Paints.—There can be no doubt that a great deal of inferior paint is sold and used—inferior from the point of view of durability which is obviously of prime importance. There are several reasons for this. The first is the craze for low prices. A purchaser seeks to buy the lowest-priced paint forgetting that it will only last a year or so and that then he will be called upon to bear the cost of repainting in addition to the expense of the paint itself. For reasons already given, it can be accepted as a fact that in painting all permanent structures it always pays best to use a first-class paint which is certain to last a long time. It is for this reason that the author has so long advocated the use of

high-class enamels which are well known to be very durable. Although the first cost is high, such paints pay best in the end.

Another reason which has probably had more to do with the popularity of cheap paints than anything else is the system followed in this country for many years past of granting repairing leases, making it compulsory upon the lessee to re-paint all outside work once in every three years and all inside work once in every seven years. Possibly such frequent re-painting may have been necessary long ago when paints in general were far inferior to the best of those made to-day, but it is now far too frequent. A really good paint should last outside from five to eight years without needing re-painting. Of course, if a lessee knows that he will be compelled to repaint at the end of every three years whatever the condition of the paint work may be, he is satisfied with a paint which will last only that length of time.

CHAPTER II

THE PRINCIPAL PIGMENTS USED IN PAINT MAKING

As already explained, most oil paints consist of four constituents, viz., a pigment, which may be white or coloured or a combination of both, linseed or other drying oil, turpentine used to thin the admixture, and a little driers to facilitate the drying by the absorption of the oxygen from the air.

The following are the chief pigments used for the purpose, arranged in order of their colour. The average specific gravity is given against each name, although it must be observed that the actual weight varies very considerably in different samples of the same material.

WHITE PIGMENTS

WHITE LEAD (*Sp. Gr.* 6·750).—This is the most important white pigment used by house painters, and possesses the advantage of being easily applied by means of a brush while it has excellent body or opacity. The composition varies slightly, but it may be described as consisting of one equivalent of lead hydroxide and two of lead carbonate. The chemical formula is $2PbCO_3.Pb(OH)_2$. There are several processes of white lead manufacture: the oldest is known as the "old Dutch process" or "stack process." In this the metallic lead is moulded in the form of "wickets" or "buckles," which may be described as being like a miniature five-barred gate. The actual process of corrosion is done in an inner room on the floor of which are placed a number of earthenware pots, containing diluted acetic acid. Upon the top of these pots is a layer of spent tan and

upon this are strewn two or three layers of the lead wickets. A platform or floor is then put in at a space a few inches above the lead; this is again strewn with tan bark upon which another series of wickets are placed. Upon this is placed still another floor with lead wickets, and so on until the top of the stack is reached. When the stack is full the room is sealed. Sometimes the larger pots are made with a ridge inside, and a coil of lead is placed in them. The fermentation of the tan bark has the effect of creating carbonic acid, and this with the other vapours converts the metal lead in from 90 to 100 days into white lead, which is then removed, crushed by rollers having corrugations, screened and ground in water, and then dried in stoves ready to be either ground and to be sold in dry powdered form, or to be afterward ground in linseed oil. In most stacks, there is something like 10 per cent. of the metal which is not corroded, and this, of course, is re-melted and serves to form new wickets.

There are many other processes, more or less used. In the chamber process, the metallic lead is made in the form of thin strips which are hung over a series of poles arranged horizontally. The necessary corroding gases are introduced into the chamber by means of stoneware pipes, and in about eight weeks the lead is found to be completely corroded.

Still another process and one which is largely used in America, is the "Carter process." By this method the metallic lead is converted into fine powder by means of high-pressure steam blast; this metallic powder is introduced into large wooden cylinders, which are made to revolve very slowly. Dilute acetic acid and carbon dioxide are introduced into the drum, and in twelve days the corrosion is complete. The result is a white lead of beautiful colour and extreme fineness.

As explained elsewhere, the fineness of all pigments has much to do with their durability when made into paint. Much of the white lead which was formerly imported into Great Britain from Germany, although pure from a chemical point of view, was very coarsely ground and therefore did not make a good paint. White lead is used as the base for many paints; it may be coloured to almost any tint or shade by adding the necessary staining or tinting colours. But those which contain sulphur in their composition cannot be used with it as the mixture would darken appreciably. Among those colours are ultramarine, sap green, yellow orpiment, King's yellow, Indian yellow, gamboge and carmine.

BASIC SULPHATE OF LEAD (*Sp. Gr.* 6·082).—This material is gaining in favour among paint manufacturers, and is particularly suitable for light-tinted paints. It is made in the neighbourhood of London, by a special process in which the ore is mixed with anthracite coal, the same heated to a high temperature; air being admitted, this yields white fumes which are collected in large bags; the air and acid escapes leaving a deposit of basic sulphate of white lead, which usually contains a considerable proportion of zinc oxide.

ZINC OXIDE (*Sp. Gr.* 5·470 to 5·554).—This beautiful white pigment has come into largely increased use in Great Britain, during the last decade. It is made in two different ways: one by burning spelter or metallic zinc, which gives off white fumes which are collected in a series of bags hung from pipes which stretch from the furnace to a considerable distance. The second method is called the " direct " method, and in this case, the zinc oxide is made direct from the ore. It is said that this process yields a zinc oxide which is better fitted for the purpose of paint manufacture, but it is

rarely pure, and almost always contains a small amount of white lead.

Zinc oxide has the advantage of being non-poisonous, beautifully white and very fine. It may be mixed with any colour or with any other pigment, without being affected or affecting them. It is the base of all the best-quality white enamels, and an important constituent of the better class of ready-mixed paints. It may be used by itself in all painted work in oil, both inside and outside; but on external work it is necessary that the thinners contain 20 per cent. of good mixing varnish. Patent or paste driers must never be used with zinc oxide. Refined boiled oil may be used and, in that case, 10 per cent. of mixing varnish for outside work will be sufficient. Liquid driers can, as a rule, be employed, and these may be purchased either in liquid form or in the form of powder, this variety being imported from France. The undercoats for zinc oxide may be lithopone (*q.v.*). This lessens the cost and gives almost, if not quite, as good a result as if zinc oxide is used throughout. Zinc, when mixed into a paint, has a tendency to become hard and somewhat brittle, and it is for this reason that many paint manufacturers mix it with white lead, as already explained. When painting is done at the seashore, white lead paint should never be used for a finishing coat, as the ozone is certain to destroy it. A finish coat of zinc oxide mixed with varnish, in the manner suggested, will be found to last very much longer. If white lead is used as an undercoat with a zinc oxide finish, there is a strong tendency towards decoloration.

LITHOPONE (*Sp. Gr.* 4·236).—This extremely useful pigment was invented by Mr. John B. Orr, now of Widnes, Lancashire. The process of manufacture is somewhat complicated, and space will not permit of a

description, but it may be said that the pigment consists approximately of 30 per cent, of zinc sulphide and 70 per cent. of barium sulphate, the two being produced together. There is often a little zinc oxide present.

Lithopone possesses remarkable body and spreading power. It is the principal ingredient of most of the "undercoatings" for paint, which are now used so largely. It is also the base of most washable water paints and of flat wall finishes. The material has the very peculiar property of darkening when exposed to sunlight, although this disappears after a time. Some grades of the material are free from this defect. It may be remarked that the presence of sulphate of barium in this pigment is no detriment to its durability. Ordinary barytes is also sulphate of barium, but the two products are as different as chalk and cheese. Artificial sulphate of barium, of which blanc-fixe is an example, has excellent body and durability.

FLAKE WHITE.—This is merely another name for the best variety of fine white lead such as is sold by artists' colourmen.

CHINESE WHITE.—This is the name used by artists' colourmen as applied to the best variety of zinc oxide which is usually put up ground in oil in tubes.

SUBLIMED WHITE LEAD (*Sp. Gr.* 6·396).—So far as the author is aware this useful pigment is not made in Great Britain, but it is produced in considerable quantities in America. It is made by burning galena, and is described by Maximilian Toch[1] as a "stable, uniform, and very valuable paint pigment." He also says: "sublimed white lead as a marine or ship paint is of much value, owing to its hardness of drying and imperviousness of film."

[1] *The Chemistry and Technology of Mixed Paints*, by Maximilian Toch (Crosby, Lockwood & Son).

Zinc Lead (*Sp. Gr.* 5·500).—This is another white pigment the production of which is restricted to America. It is made by subliming zinc and lead ores and has theoretically a composition of equal quantities of zinc oxide and sulphate of lead.

EXTENDERS

There are certain materials which may be added in more or less small proportions, to paint with advantage; but are sometimes regarded as adulterants. As a matter of fact, they can only be so considered when the amount used is excessive. If the proportions are carefully determined—and they are never very great—their addition may be, and frequently is, a distinct advantage to the paint mixture. Toch gives the following list which is repeated here as being useful for reference—

(1) Barytes; (2) barium sulphate; (3) barium carbonate; (4) silica and its various forms, infusorial earth, etc.; (5) calcium carbonate; (6) whiting; (7) white mineral primer; (8) clays, silicate of alumina; (9) kaolin; (10) asbestine; (11) calcium sulphate; (12) gypsum; (13) charcoal.

The reason why these materials are not considered under the head of the usual paint materials, is that, when ground with oil, they have but little or no body.

Barytes (*Sp. gr.* 4·401).—This material is made from heavy spar, which is ground into fine powder, and then treated with sulphuric acid to correct the colour. It is quite inert, but is very deficient in body when ground in oil. The present writer had applied to a deal board eight coats of barytes, ground in oil, but the grain of the wood and the knots could still be seen. The mineral is an important one in the paint trade, as it forms the base of nearly all the lake colours. It is largely used

in the preparation of Brunswick greens and other colours, and is mixed with white lead to form what is called "reduced white lead," an inferior quality made to meet the demand for a low-priced article. It is highly probable that if from 5 to 8 per cent. of barytes is added to white lead, the mixture would be an improvement on the pure article, because the tendency of the lead to be influenced by sulphurous fumes would, to some extent, be corrected, while the small proportion would not appreciably lower the body.

SULPHATE OF BARIUM (*Sp. gr.* 4·144).—This pigment is mentioned under the head of lithopone, and it has been shown that it possesses good body and is a most useful pigment under certain circumstances. It is made, as a rule, from heavy spar by a process of precipitation. Barium carbonate is not often used as a pigment. It may be regarded to have similar properties to precipitated sulphate of barium.

SILICA.—This material is made by reducing ordinary silica to very fine powder, and is used in a paint with the object of rendering it more fit for re-painting. It is said to give a "tooth" or a hold for the paint to be subsequently applied.

CALCIUM CARBONATE.—This is the chemical term for the ordinary pure chalk which is so much employed in the manufacture of distempers. When mixed with water, it has excellent body, but when mixed with oil, the body disappears; very small proportions are sometimes added to oil paints to correct acidity, but the presence of very large quantities would be certainly very objectionable, and would probably result in the destruction of the oil film, while it would be certain to cause "chalking."

WHITING.—The remarks under the above head apply to this material also.

CLAY.—China clay is sometimes used instead of sulphate of barium, as a base in red and lake colours. It is also useful to add to paints which are to be applied by dipping, as it holds the other pigments in suspension.

ASBESTINE.—The use of this material in Great Britain is increasing among paint manufacturers. It consists of magnesium silicate or ordinary asbestos reduced in fine powder. Its chief use is to hold the other pigments in an oil paint in suspension, and to prevent such pigments from settling in the can at the bottom. It also has an advantage in giving "tooth" or key to subsequent coats of paint, which may be applied.

GYPSUM (*Sp. gr.* 2·500).—This material is hydrated sulphate of calcium, which is usually prepared from the natural mineral by being ground to a fine powder, and treated in a special way to improve the colour which is in the finished product a beautiful white. It is largely used in the manufacture of Venetian red, which, by the by, is an exceedingly durable pigment, and it is also the base of a well-known distemper which, however, is not washable.

BLACK PIGMENTS

Most black pigments are produced by burning various materials such as refuse oil, in the case of lamp black, bones in the case of bone black, and cork, twigs, etc., in the manufacture of vegetable black; the burning of soot, which after treatment is ground in oil, already for use. Gas black is made from natural gas of petroleum origin, found in some of the United States of America, notably Pennsylvania. Ivory black should be made, as the name suggests, by burning ivory chips, but most of this colour are made of bones. There is one firm, however, in London, which continues to produce ivory black, which is really made from ivory. Pure ivory

black, when mixed with white, gives a distinct bluish cast. Gas black and lamp black, when mixed with white, yield a grey which is of a brownish cast.

Blacks are quite permanent and resist the action of acids, alkalies, oils, etc. They mix well with water, oil and varnish, and withstand a high heat.

GRAPHITE.—Few paints are more durable when applied to iron or steel, than those which are made from graphite or plumbago, a mineral which is similar with that used for lead pencils and for polishing stoves, but is different in physical structure. The graphite, when pure, if ground in oil, is, however, not quite suitable for the purpose, as it gives too thin a film. Varieties have been found which contain a considerable proportion of silica in their composition, and it is silica-graphite paint which proves to be so exceedingly durable. The explanation probably is that when ground in oil and used as a paint, it presents when dry a smooth or slippery surface, from which water very readily rolls off. As it is, of course, water in the shape of rain, which is the chief cause of the destruction of paint, it will be clear that this rolling off, like, as it were, water from a duck's back, prolongs the life of a paint film for a considerable time. Iron bridges, the overhead railways, both in Liverpool, New York and other cities, have been painted with silica-graphite paint, which has lasted from five to ten years. As the colour is sometimes thought to be objectionable —it is dark grey approaching black—some grades of graphite paints are made in dull reds, greens and browns.

The author, who has had some experience with graphite paints, believes that they have a great future. In most cases where they have been used excellent results have been obtained. A little personal reminiscence may be here set down. In most of the large cities of America flat roofs are used which are covered with sheets of tin

which are usually painted with iron oxide, and this needs to be renewed about every three years. A strong effort was made by a certain firm of manufacturers to persuade painters to use graphite paint instead. The writer, who was fully convinced by the evidence produced as to the extreme durability of such paints, inquired of a master painter in a large way of business, "Why don't you use graphite paints for these roofs?" "Well," was the answer, "you see it's too slippery and the men don't like walking on it." "But," I remarked, "that is a very small objection which could easily be dealt with. For instance, you could put sacks on the flat to give a firm footing. Think how long the paint lasts!" "Yes," returned my friend, "it lasts too darned long for my liking. We reckon to have the job of re-painting every three or four years at most—this stuff lasts nearer ten."

RED PIGMENTS

INDIAN RED (*Sp. gr.* 4·732).—An exceedingly useful colour, being quite permanent when exposed to light, and mixing readily with any other pigment without being affected. Most of the Indian red now sold is prepared artificially from copperous or ferrous sulphate. This, on being exposed to a high temperature, is decomposed and yields an Indian red which contains, in the best varieties, as much as 96 per cent. of ferric oxide. Lower grades contain from 43 per cent. up. Artificial Indian red is made from haematite, which is practically pure oxide of iron; this is crushed and levigated, and gives a beautiful deep red colour, having a purple hue. There are many different varieties of colours in Indian red depending upon the process of manufacture. This pigment may be used by itself or may be mixed with white barytes, etc., without losing much of its good qualities.

Venetian Red (*Sp. gr.* 3·560).—This colour also was formerly made from natural earth colours, but is now more usually produced by heating ferrous sulphate with lime. The colour, when made into paint, has excellent body, great durability and permanency. It is a great favourite with some of the great railway companies, when it is used as a body colour and is protected by varnish.

Red Lead (*Sp. gr.* 8·861).—This is a very ancient pigment, which is made from yellow monoxide or massicot, by heating it in an open oven. During the process the massicot is frequently raked over so as to expose the surface to the action of the oxygen. It is a very heavy pigment, much used in painting iron, and in small proportions, in the priming coat on wood. Being heavy, it settles easily in the painter's can, so that it is necessary to constantly stir the mixture between the application of each brushful. It is a good dryer, but must be used within a few hours of its being mixed with oil. When the red lead paint is dry, it forms a very hard surface, and it is therefore much used for painting wagons, bars, and other articles which have to withstand rough wear. Orange lead is very similar, in its composition, but lighter in weight and more brilliant in colour. It is sometimes used in place of red lead, because it does not settle so readily in the can.

Vermilion (*Sp. gr.* 7·726).—Is made from sulphide of mercury and sulphur, the exact process being kept very secret. It is a bright red colour, closely approaching spectrum red in hue. Although it is usually regarded as being permanent, as a matter of fact, it turns brown after exposure, unless it is protected by a coat of varnish. It is not now so much used as formerly in paints, having been superseded by "fast reds" which are equally bright in colour, and which are really permanent.

FAST REDS."—Imitation vermilions, or bright reds, were formerly made in large quantities from coal-tar colours in a variety of shades, and were quite successful, excepting that they were not very permanent, unless they were protected by a coat of good varnish. During the last few years, greatly superior pigments of this character have been produced, being free from the objections which the true vermilionettes possess. The newer pigments are sometimes known as " fast reds." They are very bright in colour, have splendid body, and are nearly if not quite permanent. They are largely used for painting signals, letter-boxes, signs, etc.

Many grades of vermilionettes dissolve readily in oil and turpentine, a quality which causes them to " bleed " through any coat of paint which may afterwards be applied over them. For example, a white enamel if applied over a red surface where a true vermilionette has been used, will be found to penetrate in the shape of small beads of red like blood. The following remarks on this subject was written by the author and published in the *Illustrated Carpenter and Builder* some time ago.

Quite frequently complaints are received from decorators that painted work done over red paint is sometimes utterly spoiled by the red colour showing through either in the form of small red spots like beads of blood, or more frequently in pink patches. The trouble occurs not only when painting over old red oil paint, but also quite as frequently when painting over red distemper. In a letter recently received from a correspondent, it was stated that a bathroom which had been finished in red distemper had been renovated with three coats of white lead in oil, followed by a coat of first-class enamel. Even after these four coats, pink patches showed through and spoiled the finish altogether.

The points for consideration in cases of this kind are,

first, how can the trouble be avoided; and secondly, what is the best thing to do when the bleeding does occur? To answer these questions it is first necessary to explain exactly how the defect is actually brought about. The explanation is simple—certain red colours made from one series of aniline dyes are soluble in linseed oil and turpentine. When a coat of paint, which of course, contains these thinners, is painted over such a red, some part of the red colour is dissolved and penetrates through the fresh coat of paint and appears to a greater or lesser extent on the surface. A second or even third coat will act in exactly the same way on that portion of the red which has come through, so that it may require several coats before the red is completely eliminated, and even then, as in the case of the bathroom referred to, the small amount of red which has appeared will mix up with the paint or enamel and produce a pinkish patch.

A few years back many of the red distempers and a number of the so-called "fast reds" or imitation vermilions, were made from aniline colours which possessed this defect of bleeding; but to-day they are not made to any considerable extent, and in executing new work in red it is always desirable to obtain from the manufacturer a guarantee that the colour will not bleed.

To make assurance doubly sure, a simple experiment should be performed. Take a small bottle, such as a medicine phial, place in it a very little of the suspected red, pour in upon it equal parts of the turpentine and oil so as to fill two-thirds of the bottle. Then give a vigorous shaking and put the bottle to rest. Examine it after, say half an hour, and if the oil and turpentine is coloured pink, the red will bleed. If, however, all the red is settled to the bottom leaving the turpentine and oil in its natural colour, it will not bleed.

Coming now to the case which occurs so frequently when a decorator is called upon to paint over a red surface—perhaps in white or some colour. The first thing he should do on every occasion is to make quite sure whether the red will bleed or not. This can be done in a very simple way by scraping off a little of the red colour from some part of the work which is not in a very conspicuous position, placing it in a bottle of turpentine and oil as before and observing the effect. As the paint is hard, it is best to shake a little longer than on the previous occasion; but if the oil and turpentine are stained, one may be quite sure that it will be unsafe to paint over the lead without taking some special precaution. The simplest way is to give one or two coats of first-class knotting which, of course, is shellac varnish; but it is better still to use one of the special materials for this purpose, as they are manufactured especially with a view of dealing with this trouble. Messrs. Goodlass, Wall & Co., Ltd., 42 Seel Street, Liverpool, make a material of this kind, as do also Messrs. Mander Brothers of Wolverhampton, and Messrs. Lewis Berger & Co., Homerton, London, N.E. One coat is usually sufficient if great care is taken not to skip any part of the work. In passing, it may be observed that the same material answers very well when it is desired to paint over tar, but in that case it is necessary to scrape or otherwise remove most of the tar before applying the material.

BLUE PIGMENTS

Prussian Blue (*Sp. gr.* 1·956).—Is made by mixing iron salts with yellow prussiate of potash. It is a very strong and beautiful colour, which, however, cannot be used with whiting or lime, and it is therefore useless in making distempers. It is usually regarded as a permanent

pigment, although there have been doubts raised on the subject. An authority says: "Prussian blue or any of its allies may be considered permanent or fugitive, according to the manner in which it is made, and according to the base with which it is mixed. If Prussian blue contains more than a trace of soluble salt 'sodium or sulphate,' it has a decided yellowing action on the oil, and a light blue or light green made of such Prussian blue is supposed to be fugitive. On the other hand, a number of experiences made with thoroughly washed Prussian blue, have demonstrated that it is a perfectly stable colour and does not change its shade." Mr. Toch warns manufacturers of ready-mixed paints against the use of Prussian blue in connection with white lead, and suggests that artificial cobalt blue mixed with zinc oxide be used in its place. Prussian blue mixes well with both oil and water; it is a remarkably strong colour, and a little will tint a large bulk of white.

ULTRAMARINE.—The artists' colour sold under this name is exceedingly expensive and is made from the mineral *lapis lazuli*. The bulk of the ultramarine sold, however, is made artificially from a mixture of clay and other substances, including sodium carbonate, which is afterwards roasted, ground and washed. The blue is somewhat red in its character; it is permanent excepting in the presence of alkalies, and, as already stated, cannot be mixed with white lead. When mixed with zinc oxide, it yields a number of very acceptable tints. It is permanent and works well in oil, water and varnish.

COBALT BLUE.—A blue with a slightly greenish hue, which yields a special blue of turquoise tint when mixed with white, in contradistinction to ultramarine which gives more or less a violet shade. It is unaffected by lime alkalies or acids, is permanent to light, and does not affect the pigments with which it may be mixed.

Many beautiful tints may be obtained by the use of cobalt blue which cannot be obtained either from ultramarine or Prussian blue.

CHINESE BLUE.—A superior quality of Prussian blue.

YELLOW PIGMENTS

CHROME YELLOW (*Sp. gr.* 5·918 to 6·875).—May be regarded as the chief artificially produced yellow colour. It is made by precipitation, from a solution of nitrate of lead and potassium bichromate. Some eight or more different shades are manufactured, varying from orange chrome to lemon or canary chrome. The lighter shades usually contain a proportion of lead sulphate. It is a very useful colour, having good body, but is open to the objection that being a lead compound, it is affected by sulphurous fumes and sulphur in other pigments such as ultramarine, cadmium yellow, etc.

ZINC YELLOW.—This is a chromate and hydrate of zinc. It possesses the advantage of being non-poisonous. Zinc chromes are of delicate tints and are useful in certain decorative work. The body is good and the pigment is not affected by sulphurous gases. As it does not affect pigments with which it may be mixed, it can be used for certain purposes where chrome yellow would be objectionable.

OCHRE (*Sp. gr.* 3·107).—Red and yellow ochres are natural earth colours, which are extremely useful to the house painters, not only because of the relatively low cost, but also because of their permanence. They largely vary in colour, according to the place where they are found, and undergo the process of grinding and levigation for the painter's use. The brightest class of ochres are called "Oxford ochres," although the deposits on the Oxfordshire district were long ago exhausted. The colour being the most important attribute, "Oxford

ochre," "golden ochre," and other of the bright varieties are frequently adulterated with chrome yellow or other colours to improve their appearance. Burnt ochre is, as its name would suggest, an ochre which has been calcined. When mixed with white, ochres produce a series of buffs or creams, according to the quantities added. Ochre is used as a body colour, *i.e.*, without admixture, and also is employed largely by grainers, in which case, it is necessary to grind it exceedingly fine. The composition of ochres varies very largely. But the chief constituents are silica, alumina and ferric oxide.

SIENNA (*Sp. gr. raw* 3·081, *burnt* 3·477).—This pigment may be regarded for practical purposes as having the same properties as ochre, with this great difference, that most varieties are very much more transparent when ground in oil. The colour is also used, to a considerable extent, by grainers, and is employed in tinting white lead and other white bases, as it does not change the colour of any other pigment.

Burnt sienna is of deeper colour than raw sienna, it being of a bright orange hue. Very beautiful tints are obtained by heating the raw material. Analysis tells but little as to the value of a sienna, as it would only yield various proportions of ferric oxide, alumina and silica. It is the richness and colour, tint or shade of the sienna which determines its quality when taken into consideration with body and covering property.

GREEN PIGMENTS

CHROME GREEN.—Originally chrome green was known as Guignet's green, which is oxide of chromium, and a pigment under that name is still made and possesses distinct advantages over the ordinary chrome green, which is merely a mixture of chrome yellow and

Prussian blue. More frequently the liquids necessary for producing those two pigments are themselves mixed together, yielding a chrome green, which is quite homogeneous. It is made in a variety of shades and possesses excellent body. Many qualities of chrome green are made, some being mixed with a large proportion of barytes, in which case it is usually sold as "Brunswick green."

EMERALD GREEN (*Sp. gr.* 2·713).—This pigment may be said to closely approximate in hue the true green of the solar spectrum. It contains more than half of arsenious oxide and a very large proportion of copper oxide. Because of its marked poisonous character it is now very little used by house painters, there being on the market pigments of the same hue which are free from poisonous qualities. In America the pigment is known as Paris green, and it is there largely used as an insecticide. Emerald green may be mixed with all other pigments excepting those containing sulphur. It was the use of this green which gave rise to the poisonous wall-paper scare some thirty years ago. But emerald green is now never used in the manufacture of wall papers for one reason—because non-poisonous greens are easily obtainable which are far cheaper.

VIRIDIAN.—This colour is also known as Emerald oxide of chromium and Guignet's green (*see* chrome green). It is one of the most permanent greens known; is brilliant and permanent. It has a slight yellowish tone, good body and mixes well with other colours without affecting them or itself being affected.

Cobalt green, Verdigris, and Malachite are the names of other greens which do not, however, call for any particular description.

TERRA-VERTE is a natural green earth which possesses remarkable durability under all conditions. The green

colour is not very brilliant, but the pigment is valued because of its permanence. It is related by Prof. A. P. Laurie, the Chemist to the Royal Academy that he examined small particles of the colours used by the old masters and found that they were all natural or earth pigments, even the greens employed being terra-verte. Terra-verte is sometimes called "green ochre" owing to its similarity of composition. It is sometimes called "Verona green."

THE EARTH OR NATURAL PIGMENTS

Most of the pigments under this head are mined from the earth and require either grinding or the process of levigation or both to fit them for paint-making. The most usual system of levigation consists of a series of tanks or pits containing water so arranged that the finer particles are carried in suspension from one to the other leaving the coarser and gritty matter behind. The different grades are then dried.

OCHRE (*see also* under "Yellow Pigments").—This valuable pigment is found in many parts of the world and varies considerably in colour from grey to a bright red. The colouring matter is ferric oxide or iron rust. Sometimes barium sulphate is present in large quantities. The proportion of ferric oxide present determines to a considerable extent the strength of colour, but the richness of tone is of importance. Golden ochre is a variety having a particularly rich colour, and is often imitated by the addition of orange chrome yellow.

There can be but little doubt that very large quantities of ochre exist in various parts of the world which would be available for paint making purposes. Some have excellent body, others a rich colour which render them valuable for admixture with other pigments.

Burnt ochre is used to a considerable extent in the United States, but in England it is only employed as an artist's colour. Ochres possess several great advantages. They are very durable, relatively cheap, and are very durable when mixed with first-class thinners. The very cheapness has to a certain extent caused them to be extensively used in low-priced paints in which inferior thinners are employed, the result being that they do not last very long. But their failure in such cases is not due to any defect in the pigment but to the oil employed in thinning.

Not only do ochres make good paints in any vehicle—oil, water or turpentine, for example—but they may be safely mixed with any other pigment without affecting it or being affected. They are not affected by sulphurous compounds or impure air.

UMBER (*Sp. gr.* raw, 3·496; burnt, 3·578).—This is another pigment of the same class as the foregoing but is of a different colour, being dark brown with a slight purplish (not red) hue. When burnt it is a very rich brown. The composition usually includes a larger proportion of manganese than is usually found in either ochre or sienna. Like these, however, umbers vary very much both in colour and composition but they possess their chief virtues, viz., durability and that of being unaffected by other pigments with which they may be mixed.

VANDYKE BROWN.—This is another brown richer and redder than umber. The composition of the natural earth is different, as 50 per cent. or more is of organic origin. It dries slowly and irregularly but does not affect any other pigment with which it may be mixed. A great deal of imitation Vandyke brown is sold which is prepared by mixing together various proportions of black, ochre and red oxide. A better variety is made

by burning vegetable refuse, cork, etc. Among wood finishers, cabinet makers and others, a material known as "vandyke crystals" is used for staining purposes. This is made by treating natural vandyke brown earth with ammonia afterwards filtering and drying.

Other natural colours have already been described.

CHAPTER III

THE THINNERS USED IN PAINTS

As already stated, the principal thinners used in ordinary house paints are linseed oil and turpentine, each of which may be substituted by other products. The subject of drying oils has been dealt with at length in another book in this series.[1]

To the information given therein may be added the following—

Raw linseed oil is used by painters to thin their paint previously ground in the same oil, and is further thinned by the addition of turpentine. The quantity required for producing a consistency of paint for being applied with a brush varies with the pigment and particularly with the surface to be covered, as to whether it is absorbent or not. On a non-absorbent surface, 1 cwt. of white lead will require rather less than 2 qt. of linseed oil and 2 qt. of turpentine. Mixed in this way the quantity named will cover 700 sq. yd. Boiled linseed oil is sometimes used on outside work to facilitate drying; 25 to 50 per cent. of the boiled oil should be added to raw oil for this purpose. Among the other drying oils which are used to a very limited extent, however, are the following—

	Specific Gravity at 60° Fah.
Linseed, raw	·931 to ·935
„ bleached	·929 „ ·934
„ boiled	·933 „ ·945
Poppy seed oil	·924 „ ·938
Soya bean oil	·924 „ ·927
Tung or Chinese wood oil	·934 „ ·944
Walnut oil	·925 „ ·927
Hempseed oil	·925 „ ·931

[1] *Oils, Animal, Vegetable and Mineral*, by C. Ainsworth Mitchell (Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, W.C.2).

Bleached linseed oil is very useful when mixing white and light coloured paints, and poppy-seed oil is useful for the same reason. Tung or Chinese Wood oil is largely used in the manufacture of flat wall paints and in varnish making generally. Walnut or hemp seed oils are restricted in their use to artists.

TURPENTINE.—Genuine American turpentine has always been regarded as the finest article of its kind, although French turpentine is sometimes used in its place, and in late years certain substitutes of petroleum origin to which reference will presently be made. Russian turpentine may be dismissed with the remark that it is unsuitable for painters' use as it contains, even after careful distillation, certain tarry compounds which cause it after a time to darken considerably in colour while at the same time it assumes a very disagreeable odour.

American turpentine is made from the gum or resin which exudes from many different varieties of fir trees, the principal of which is the pitch pine (*Pinus Australis*) or the Georgia Pine of the American carpenter. This is a wood similar to pitch pine. Incisions are made in the lower part of the tree and the crude resin flows into receptacles provided for the purpose. In order to increase the flow the wound is frequently scraped. According to McIntosh trees of full growth receive from two to four "boxes" or receptacles, so that 10,000 boxes are distributed among 4,000 to 5,000 trees in an area of 200 acres. The 10,000 boxes yield at each dipping about forty barrels of "dip" or "soft gum," or about 240 lb. net weight.

The crude resin is distilled and yields pure turpentine which is given off as vapour and is cooled to form the turpentine of commerce. There is a considerable quantity of solid material left which, when purified,

becomes ordinary rosin. Pure turpentine is a white mobile liquid. The specific gravity at 60° F. is from 0·865 to 0·867; and the boiling point 155° to 157°. The specific gravity can readily be ascertained by means of an ordinary hydrometer.

TURPENTINE SUBSTITUTES.—Some twenty years ago, most of the varnish substitutes sold were merely a mixture of American turpentine and light petroleum oil. They were not a great success, as the oil retarded the drying of the paint with which it was mixed. After some time white spirit, a product of petroleum oil, was introduced, and although at first painters, varnish manufacturers, and others were rather shy of it, it is now used to an enormous extent and is found for most purposes quite as good as genuine American turpentine.

Quite frequently the spirit is mixed with some 20 to 30 per cent. of turpentine in order to give it the characteristic smell. It is made in various grades according to the purpose for which it is required, varying from 80 flash-point up to 115, or even more for use in tropical climates. The lower flash-points are used in the manufacture of quick drying paints. Decorators use white spirit having a flash-point of about 90 to 91 which is the same flash as genuine turpentine. It is important that the spirit wholly evaporates when mixed with paint leaving nothing behind as the heavier oil would do. The spirit should be practically free from smell and be water white. A rough test is to dip a piece of blotting paper into the white spirit and hang it up to dry. If it is suitable for paint the blotting paper after, say an hour and a half, will be quite free from any stain or smell. In other words, the whole of the spirit would have evaporated.

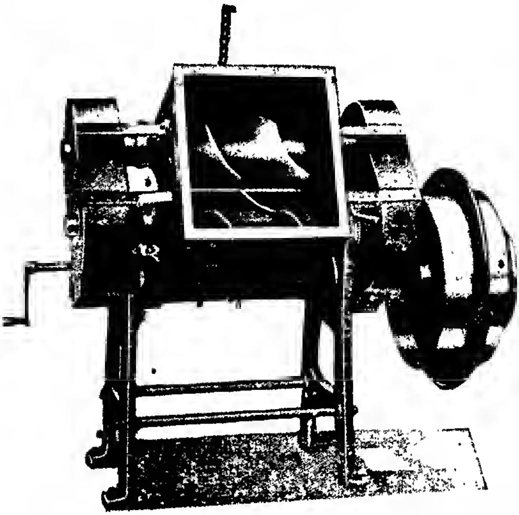
The United States Naval Department have issued a specification for this material which calls for the

following conditions. The spirit must be pure, sweet, clear, water white, and strictly neutral in reaction. When a sufficient quantity of the liquid is mixed with pure, dry white lead to form a creamy paste and spread on a clean glass plate maintained at a temperature of 250° F. for two hours, there shall be no perceptible darkening or change in the colour of the white lead. The flash-point is given at 85° F. in a closed Abel tester, and 100° F. was determined in an open tester. The specific gravity should be 0·800.

Turpentine substitute is not a success when mixed with paints having a bituminous or asphaltic base, but when mixed with white lead, zinc oxide, the lakes, and all the earth colours, such as sienna, ochre, etc., it acts precisely in the same manner as genuine turpentine does. It is also unsatisfactory mixed with very cheap paints containing rosin. The price of white spirits before the war was about one-fourth that of turpentine. Another point worthy of mention in connection with white spirit is that it does not deteriorate by keeping. Turpentine, on the other hand, ultimately becomes "gummy," and in that condition is useless for paint.

BENZOL.—This material is not used by painters in this country, although it is a favourite in America, particularly for use with stains. It may be described as a light naphtha derived from the distillation of coal tar. It is a perfect solvent of paint, and is therefore a constituent of most of the modern paint removers. It has the peculiar property of penetrating wood to a greater extent than any other known liquid, and a proportion of benzol may therefore be used with advantage for priming coats of paint. Painters' brushes which have been rendered useless by being hardened in the bristles, may be made almost as good as new if they

are soaked in benzol for a few hours. But it is necessary, during that time, to agitate them, dabbing them against the bottom and sides of the vessel in which the benzol is contained, in order that the material may penetrate and soften the paint.



" UNIVERSAL " KNEADING AND MIXING MACHINE

CHAPTER IV

PAINT-MIXING. THE APPLICATION OF PAINTS, ETC.

SOME information has already been given as to the method of mixing paints, a process which is carried out in a paint factory by means of paint-mixing machines, examples of which is shown in Figs. 5 and 6. White lead (if such is to be used for the base) is first broken up, linseed oil being added, the colour is previously thinned with turpentine and this is added when the white lead has been reduced to a thin paste. If the turpentine is added before the oil results are not so good. The colours which would be used to produce any given tint are set out at length in the author's book, *Paint and Colour Mixing*, published by E. & F. N. Spon, but a few of the important colours may be given here by way of a guide.

Greys are mostly produced by mixing white and black together, the former predominating. For a French grey, a little cobalt and Venetian red may be added, or a little orange chrome to give it a slight violet tinge. Olive grey is produced by adding about three parts of lampblack to one of chrome green, and forty times the quantity of white lead. Pearl grey is made by adding a little vermilion and deep chrome green to white lead; or Venetian red alone answers the purpose.

Red colours may vary from a rich scarlet or crimson to a delicate light pink. For brilliant colours alazarin, crimson and scarlets which approach the brilliancy of madder lakes, are employed, and if zinc oxide is used as a base a large range of beautiful pinks and reds may be obtained. For the more sombre reds French ochre

and Venetian red are added to white lead which gives a good brick colour. Claret is produced by a mixture of two parts of carmine with one of ultramarine. Flesh colour, by adding a little ochre and Venetian red. Indian red is also a very useful colour for producing the less brilliant red mixtures. To produce lilac, Indian red and a very little lampblack may be added as a tinting colour to white lead or zinc oxide. Plum colour is made of equal parts of white lead, Indian red, and ultramarine, but add twice the quantity of white lead. Terra-cotta may be made by mixing two parts of white lead to one of burnt sienna, but the tone can be varied by the addition of Venetian red, umber or chrome with a little lake if thought desirable.

Yellow colours are mostly produced from yellow ochre, chrome yellow in its various shades, and zinc yellow. Biscuit colour is best produced by tinting zinc oxide with Naples yellow. Another way is to use ochre added to white with very little umber. A series of buffs, creams, and stone colours are produced by mixing white lead with French yellow ochre, with or without a little Venetian red. For artists' purposes Naples yellow and zinc oxide give the best results. The darkest stone colours may have the addition of very little black or umber. Primrose requires a little green added to yellow, such as middle chrome.

Coming now to the greens, we have chrome green, a commercial variety of which is a mixture of Prussian blue and chrome yellow which, when mixed with white, gives a series of bright greens. This brightness may be toned down by using burnt sienna and umber in proportions depending upon the brilliancy of colour desired. A grass green is merely a light chrome green. An olive green has black and burnt sienna in its composition, while olive is produced from ten parts of

lemon chrome yellow, one part of ultramarine blue, and one part of light Indian red. Quaker green is made by a mixture of equal proportions of Venetian red and medium chrome yellow to which is added a little blue black.

Browns may be dismissed with the remark that they are nearly all produced from natural earth colours with the addition, where necessary, of a little black, and now and then very little brilliant red.

The following mixtures are recommended as being of exceptional durability, and any suitable colour can be added so long as the proportions of the base are maintained—

OLD WORK.

100 lb. pure white lead.
25 lb. pure white oxide.
5 lb. barytes or asbestine.
4 gall. pure raw linseed oil.
1 gall. pure turps.
1 pt. japan drier.

Add ½ gill of benzol (160°) to each gall. of paint in the pail just before using.

Makes about 8 gall. of paint.

100 lb. of lead bulks 2¾ gall.

NEW WORK.

100 lb. pure white lead.
25 lb. pure zinc oxide.
10 lb. barytes or asbestine.
6 gall. raw linseed oil.
1½ gall. pure turps.
1½ pt. japan drier.

Add ½ gill of benzol (160°) to each gall. of paint in the pail just before using.

Makes 10 to 12 gall. of paint.

FINISH COATS.

100 lb. pure white lead.
25 lb. zinc.
10 lb. asbestine or barytes.
4 gall raw linseed oil.
1 pt. pure turps.
1 pt. japan drier.

Makes about 8 gall. of paint.

It is deemed desirable to point out that the above recipes are of American origin, hence the addition of asbestine and benzol. British makers would probably omit these, although their presence has been proved to be a distinct advantage. As already intimated, the asbestine assists in forming a "key" or hold for subsequent coats of paint, while the benzol used in the first coat on old work or the priming coat in new work is an aid in causing the paint to penetrate and hence to hold on to the wood. Naturally the benzol would not be required when painting on iron or other non-absorbent surface.

It should also be observed that the quantities of the liquids are given in American gallons which are about one-seventh smaller than an Imperial gallon. Inasmuch as the exact proportions will vary so much with the surface and the particular branch of pigment employed, it has not been thought necessary to alter them.

In mixing colours and paints it is very necessary to eliminate all "specks" or hard pieces of material which would seriously mar the appearance of the work if they were allowed to remain. With this object the paint is usually passed through copper gauze strainers of varying mesh; the first strainer being somewhat coarse, the second finer, and the third very fine. If this is done, the paint will be quite free from "specks" and will go on smoothly and evenly. Few painters, as a matter of fact, take the trouble to strain their paint three times, but to do so really pays because so much time is saved in rubbing down with glass paper between the coats.

THE APPLICATION OF PAINT.—The subject of painting hardly falls within the scope of this book, but a few remarks on the subject may be made.

Some paints may be applied very much more easily by means of a brush than others. White lead being really a lead soap is spread quite easily; zinc oxide is a little more difficult, while graphite paint is the easiest of all. Journeymen painters strongly object to use paints which "pull" on the wrist, as is the case of some of the thick enamels, and cases have been known where a painter has surreptitiously added turpentine to his enamel in order to make it easier of application, but with the result of pactically ruining the work.

As a rule, paint is applied by means of brushes made from hogs' bristles and vary largely in size and shape. For the bulk of the work pound brushes are used, the name originating from the fact that formerly about 1 lb. of bristles was necessary to make a good-sized brush. Smaller brushes are called sash tools, which are used to paint the smaller mouldings, sash bars, etc., while fitches are still smaller brushes employed for lining and "cutting in" the work at its extremities.

In painting wood, plaster, stone and other absorbent materials it is necessary to use a considerable amount of oil for the priming or first coat. On such work 10 lb. white lead, mixed with the necessary driers and thinners, will cover about 40 sq. yd. The following mixtures will be the quantity of the different materials required for three-coat work for 400 sq. yd.—

First Coat.

100 lb. white lead.
$6\frac{1}{4}$ lb. paste driers.
4 gall. 22 gills linseed oil.
25 gills turpentine.

Second Coat.

67 lb. white lead.
4 lb. 3 oz. paste driers.
1 gall. $1\frac{1}{2}$ gills linseed oil.
1 gall. $1\frac{1}{2}$ gills turpentine.

THIRD OR FINISHING COAT.

67 lb. white lead.
6¼ lb. paste driers
2 gall. 3 gills linseed oil.
½ gall. turpentine.

It will be observed by examining these figures closely that the first coat contains much oil in order to provide for the absorption. The second coat has very little oil because it is a principle of importance to follow in mixing paint to alternate the different coats, however many there may be, so that an oily coat follows one with very little oil, and *vice versâ*. In the third coat a considerable amount of oil is used in order to yield a glossy surface. Many painters add red lead to the priming coat, and in that case a smaller quantity of the paste driers will be needed, or they may be omitted altogether as red lead is in itself an excellent drier. Other painters, in order to add to the gloss of the finishing coat, put in a little mixing varnish which not only improves the appearance of the paint, but also its durability. It is important, however, that the varnish be selected with great care so that it will mix properly with the other constituents of the paint.

Perhaps the most important point to observe when applying paint by means of a brush is to use as little of the paint as possible so as to produce a thin coat. In other words, paint should be what the painters call "well brushed out." There is a tendency nowadays for painters to mix their paints too thick. This is done in order to save coats. Now a thick coat of paint has too much pigment and too little oil in its composition. It is the oil in combination with the pigment which resists the action of the weather, and if too little of it is used such paint is certain to prove the reverse of durable. Two thin coats of paint will last very much longer than one thick coat and for the reason stated. The methods

of mixing paints, and the proportions of materials to be used have already been dealt with.

In recent years a great deal of painting has been done by means of spraying by compressed air and also by dipping. Quite recently the spraying process has been made to apply to ordinary house painting. In Fig. 1

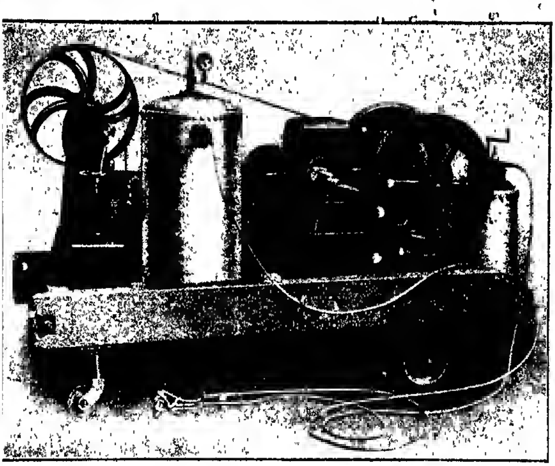


Fig. 1
PORTABLE PAINT-SPRAYING PLANT

is shown a paint-spraying plant and in the frontispiece the front of a house being painted by means of the spray, in this case, that of the Aerograph, Ltd., which was the first machine of the kind on the market. It will be observed that the work is done from a painter's cradle, or scaffold, suspended by ropes by which the cradle can be raised or lowered, or shifted horizontally as may be required. The motive force for the compressed

air is contained on a platform, mounted on wheels by which it can be shifted from place to place. In Fig. 1 is shown a 3 h.-p. petrol engine painting outfit in which the air compresser will give sufficient compressed air for two painters. The dimensions of this outfit are 6 ft. long by 4 ft. high by 2 ft. 7 in. wide. The net weight is 7 cwt. 3 qr. The compressed air is taken from the central container and is delivered to the handpiece or spraying apparatus proper by means of flexible tubing. This compressed air is also utilized to feed the paint from the paint pot to the sprayer. Air enters the paint pot through a reducing valve which is utilized to regulate the pressure on the paint and so control the flow of paint to the handpiece. The standard sizes of the paint pots are either one or four gallons, and larger ones can be supplied if desired. The best results are obtained when the paint pot is kept near to the operator, but if necessary the air can be carried to a distance of 100 ft. to the air pump provided that sufficient air tubing is available.

The actual spraying apparatus is of a comparatively simple character. It is actuated by pressing a lever which releases both the paint and air at the same time and causes the paint to be ejected in a fine spray. Nearly every paint or enamel may be applied by means of this appliance and the air pressure will vary with the character of the liquid from 20 to 35 lb. per square inch.

The remarkable speed at which painting can be done by this method may be realized when it is said that at least three, and in some cases more, square yards can be evenly painted in one minute.

The painting of ships can be successfully carried out by this method, and the idea which prevails that work accomplished in this way is of a rough character

is entirely erroneous. The actual surface is much smoother than if the paint were applied by means of a brush.

Another objection of a purely theoretical character to painting by means of compressed air is, that the durability is affected by the thinness of the film. This, however, has no existence in fact. The film being more uniform in thickness is likely to last longer than one which is not uniform. The fact that the process is used for painting a very large number of articles such as bicycle lamps, motor-cars, gas meters, safes, etc., is evidence of its durability. It is also employed for photographic and delicate artistic work

THE ECONOMY OF RE-PAINTING.—The somewhat interesting title was recently given in a London daily paper to the reproduction of a photograph of some houses being repainted. This remarkable statement was made : " In spite of the Economy Campaign, Downing Street is getting a new coat of paint." The remarkable point about this paragraph is, that the writer evidently does not appreciate in the least the fact that paint is applied principally with the object of preserving the surface, and not, as a rule, with any decorative object. And it cannot be too strongly urged upon property owners that the use of paint is just as necessary an expense as is the payment of insurance. One provides for a recompense in the case of fire occurring, the other provides for the decay due to the elements which is inevitable.

Elsewhere in this little volume reference has been made to the pernicious custom of leasing property with the provision that all exterior work must be re-painted at intervals of three years. It has also been pointed out that, provided a good paint is used, a much longer period should elapse before re-painting became actually necessary. On the other hand, it must be admitted

that much paint which is used is of a very inferior quality and soon requires renovation.

To speak of postponing re-painting work which requires attention in this respect is more than absurd. The owner of a freehold property, who is under no obligation to re-paint at all, will find that the longer he postpones the work the more it will cost him, but beyond that is the fact that some parts of the structure, particularly ironwork, may, and probably will, be seriously affected in the meantime. Speaking approximately, it may be accepted as a fact that when a coat of oil paint has lost its gloss repainting becomes necessary.

THE WEIGHT OF PAINTS.—In the foregoing description of the various pigments the average specific gravity has in each case been given, and this gives at once the weight per gallon of the dry pigment by merely changing the decimal point one place to the right. Thus, the specific gravity of zinc oxide is given at 5·470. These figures are, of course, based upon the weight of a gallon of distilled water weighed in the air at 62° F. which is 10 lb. The English gallon, it will be remembered, contains 277¼ cub. in., and specific gravity may be written as 1·000. The actual weight of one gallon of dry zinc oxide (taking the above-mentioned specific gravity) is 54·7 lb. In other words, 54$\frac{7}{10}$lb. White lead (Dutch process) has a specific gravity of 6·750. The weight of a gallon, therefore, would be 67·5 lb., or 67½ lb. So much then for the weight of the dry pigment or colour, whichever it may be.

We have next to consider the weight when such dry pigment or colour is ground with linseed oil. Below will be found a table giving the average amount of oil necessary in different pigments to produce a paste of average stiffness, but it should be remarked that even the same materials, say ochre, vary enormously in the

quantity of oil actually required. It may also be remarked that there is nothing very definite about "a paste of average stiffness." However, the figures will serve as a guide.

QUANTITY OF OIL REQUIRED TO GRIND 100 PARTS BY WEIGHT OF THE FOLLOWING DRY PIGMENTS.

	Jennings.	*Gardner.*	*Hurst.*	*Smith.*[1]
	%	%	%	%
White lead (corroded)	7	9	7½	6½ to 7
Oxide of Zinc	14	17	22	10 to 12
Barytes	8	9	7	7 to 10
Ochre	30	28	–	25 to 40
Lithopone	12	–	–	10
Raw Sienna	45 to 90	40	–	90 to 128
Brunswick Green	12	–	11	15 to 20
Brunswick Blue	13	–	–	14
Vandyke Brown	45 to 75	–	40	100
Raw Turkey Umber	45	38	–	66
Chrome Yellow (genuine)	15	20	–	12 to 16
Burnt Sienna	50 to 100	45	37½	85 to 104
Ultramarine	30	27	–	30 to 37
Prussian Blue	50 to 90	56	–	100
Lampblack	80	72	27	90
Sulphate of Lead	10	–	–	8
Whiting / Paris White	20 to 24	–	–	23
Oxide of Iron	20	–	–	18 to 22
Drop Black	75	–	–	60 to 80
Vegetable Black / Carbon Black	90 to 118	–	–	100 to 110
Lime Blue	27	–	–	25 to 30

Taking these figures, and having the weight per gallon of the dry pigment, it is easy to calculate the weight of a gallon of stiff paste when ground in linseed oil, the weight of which is 9·31 to 9·35 lb. per gallon. Suppose that the weight is taken, for the sake of simplicity, as being the same as water, 10 lb. per gallon, and that one-tenth part of oil is required to grind it to a paste.

[1] *The Manufacture of Paint*, by J. Cruickshank-Smith, B.Sc. (Scott, Greenwood & Son).

White-lead (corroded) dry, weighs 67·5 lb. per gallon. When ground in oil, one-tenth part will be oil, and therefore we subtract one-tenth of the weight of pigment, giving 60·10, and add the weight of the tenth part of oil, viz., 1 lb., giving the weight of the gallon of stiff paste at 61·10 lb.

The weight of a paint mixed ready for application can be ascertained in the same way. Taking dry white lead again as weighing 67·5 lb. a gallon and oil at 10 lb. a gallon (in the trade it may be mentioned this oil is almost invariably sold at 9 lb. to the gallon), we have discovered that the weight of a gallon of stiff paste is 60·10 lb. To mix this into paint of a workable consistency will require about 2 gall. of oil and ½ gall. of turpentine. Hence, we have 60·10 + 9·33 (weight of 1 gall. oil) × 2 + 4·3 (weight of ½ gall. turpentine) which equals 83·06 lb. for the 3½ gall., or, say 23·73 lb. per gallon.

CHAPTER V

WHITEWASHES AND DISTEMPERS

THE cheapest form of paint is whitewash which, however, need not necessarily be quite white, but may be tinted with ochre, sienna, umber, vandyke brown, and other earth colours. It is usually made from slacked lime, 5 lb. to the gallon of water. Sometimes alum, waterglass, or glue are added to improve the adhesion. A favourite recipe which is said to have been originally issued for use on lighthouses in the United States, is as follows: "Slack half a bushel of unslacked lime with boiling water keeping it covered during the process. Strain it, and add a peck of salt dissolved in cold water; 3 lb. ground rice put in boiling water and boiled to a thin paste; ½ lb. pure Spanish whiting, and 1 lb. clear glue dissolved in warm water. Mix these well together and let the mixture stand for several days. Keep the wash thus prepared in a kettle or portable furnace, and when used put it on as hot as possible with painters' or whitewash brushes."

For a cheap wash for outside work which will not wash off the following method will be found to be excellent: Mix together ten parts of Portland cement and one part fine sand, or if desired instead of the sand, one part of chalk or plaster of Paris may be used. To this must be added one part of concentrated glue reduced to a size by means of boiling water. Any natural colour may be added in small proportions to obtain a desired tint, such as ochre, Indian or Venetian red, umber, Vandyke brown, etc., but the essence of success depends upon the

Portland cement and the glue. This wash, it should be observed, is only successful when the surface to which it is applied is rendered thoroughly wet before the application is made. If the wash is applied when the weather is very hot and the sun strikes the work it will probably be unsuccessful unless it is kept quite wet. The Portland cement needs moisture to enable it to set properly, so that in this particular case the conditions are exactly the reverse of those which prevail in the application of oil paint.

One variety of distemper called "Alabastine," which is not washable, has a very large sale in all parts of the world and is made on a base of plaster of Paris, the necessary colours being added. A very ingenious arrangement has been made by the manufacturers with the object of rendering it unnecessary for a painter, or paint dealer to stock a large number of different colours. They provide their material in powdered form, and in only three colours, red, blue and yellow and white. They issue colour books showing some forty different colours which are made by a mixture of these three colours and white, and they give the proportions in each case. Many different useful tints can be obtained in this way.

Washable Water Paints or Washable Distempers.—These materials have gained rapidly in favour during the last ten years or so, and may be regarded as a superior distemper which possesses the property of resisting moisture to the extent that they may be washed down when desired by means of a sponge and hot water. Few of those on the market, however, will withstand scrubbing. They are mostly made on a base of lithopone, and are produced in a very large number of handsome colours. They are applied by means of large wall brushes and produce a surface quite free from

gloss, and one which gives a most acceptable background for pictures and furniture. In some cases, particularly where the room is large, ornamentation is introduced by means either of paper borders and friezes or by stencilling such ornamentation on in suitable situations.

There are three principal grades of these paints, the first of which is supplied in a dry powder ready to be mixed into a paint by the addition of hot or, in some cases, cold water. The second variety (the one which is most largely used) is supplied in the form of a stiff paste which is thinned to the desired strength by the addition of the proper amount of water. One coat, as a rule, is sufficient, but two are often given to produce a perfectly level and uniform surface. The third variety is also supplied in paste form, but requires the addition of what is known as "petrifying liquid" which hardens the mixture and increases its durability.

A word or two of warning may be given at this point as to the application of these paints. Sometimes they are applied over wallpaper, but if the paper is a cheap one the pattern is likely to work up under the brush and to give a patchy appearance. In the case of old walls it frequently happens that repairs have been made to the plaster from time to time, and that such repairs have not always been done with the same material. Perhaps plaster of Paris has been employed in one case, and Keen's cement in another. Now the absorbent values of these different plasters is not the same, so that the patches are likely to show. In such a case, the best plan to follow is to remove all old paper to the plaster, then to line it, *i.e.*, hang plain lining paper all over the wall. This will form an excellent ground for the washable distemper. Of late there have been certain patent plasters produced, such as Selenitic, which

set hard with a perfectly smooth surface approaching that of glass. Now, if the distemper is applied to such a surface, it will inevitably "shell off," because there is no adhesion between the distemper and the plaster. The only practical way to deal with such cases is as follows: A sharp coat of paint, which means a paint mixed with very little oil and plenty of turpentine with a few drops of gold size, must be applied just as soon as the plaster is hard enough to withstand the pressure of the brush. In the painter's parlance "the brush must follow the trowel." The procedure results in the coat of sharp paint forming part of the plaster as it is amalgamated with it as such plaster sets. It gives a comparatively rough surface to which the distemper may be applied without fear of it coming off. It should be added, however, that it is useless to apply such sharp paint, even the day after the plastering is done; it must be applied within say, half an hour of the plaster being rendered.

The successful application of washable distemper depends upon the ground, and some plasters are very "hot" and absorbent requiring the application of some form of size or preparatory coat. Ordinary glue size is not of much service for this purpose. Gold size thinned by the addition of a considerable quantity of turpentine sometimes answers, but, as a rule, it is safest to use the special material produced by the manufacturers for this particular purpose. When "petrifying liquid" is used to mix the distemper, as is necessary in the case of certain brands, a larger proportion of this liquid should be used in the priming coat, and this will form an excellent foundation for the second or finishing coat the two together usually making a good job.

Flat Wall Paints.—This class of paints may be said to be of quite modern introduction, but it is not

improbable that their superiority over washable water paints would eventually cause the latter to be withdrawn from the market, at least to some extent. Flat wall paints are made on a basis of lithopone, but one of the important constituents used in their manufacture is tung, or Chinese wood oil, which possesses the property of resisting water and moisture. These paints are capable, therefore, of being washed or scrubbed within forty-eight hours of their application. They are extremely easy to apply and have excellent body, so that one coat is usually sufficient. They may be varnished if necessary, but without this they yield a most agreeable flat surface which, from a decorative point of view, is very acceptable. The price is by no means excessive, and these paints are made in a large variety of beautiful colours. As a rule, they are supplied in a condition ready for application.

Although this class of paint is intended principally for application to plastered walls, it may be used on woodwork with excellent results provided that one or two coats—one is usually sufficient—of really good varnish are applied over it. Without such varnish the surface, being without gloss, would be likely to "catch the dirt," but with it the woodwork will last a long time, while the cost will not be greater than that of four coats of ordinary oil paint of first-class quality.

The extent to which this class of paints has come into use can be understood from the following paragraph which appeared in a recent issue of *The Decorator* under the title of "Flatting Oil": "It will interest many readers to learn that the National Lead Company of New York has just placed on the market a new product called 'Flatting-Oil' which is intended for interior painting with pure white lead. It is described as 'a combination of pure vegetable paint oils to which

turpentine and high-grade mineral oils have been added as volatile thinners. When mixed in the right proportions with pure white lead the flatting-oil makes a paint which really flats, and which is soft to the eye, silken in texture, and truly washable. It is also extraordinarily workable, flatting out smoothly and easily, and gives a finish free from brush marks, laps, joints, or streaks.'

"The reader will readily recognize that the paint thus produced bears a close resemblance to the flat wall finishes which have gained so much in popularity during the last few years, and which bid fair to be even more popular in the future. The difference, however, is, that while lithopone is the base of most of the flat wall finishes, the flatting-oil is intended to be used with white lead. It does not require much imagination to come to the conclusion that the flat wall finishes referred to are making serious inroads into the white lead industry as far as interior decoration is concerned. The National Lead Company, which is, of course, an enormous concern, have, with characteristic enterprise, dealt with the situation by bringing out this flatting-oil which in effect means that the painter can make his own flat wall finish because he may mix any stainer he likes to produce any colour required, excepting, of course, ultramarine, cadmium yellow and other colours containing sulphur."

How A Paint Dries.—An ordinary oil paint becomes hard by absorbing oxygen from the atmosphere, and it is therefore imperatively necessary to well ventilate a room in which painting is being carried on. This is usually done by partly opening the window, and sometimes also the doors. A point, however, of precaution should be noted that if the atmosphere is humid, or very cold, it is very inadvisable to create a draught of

cold air immediately after varnishing has been done. The effect is to cause "blooming," or a cloudy effect on the surface of the varnish. Complaints are frequently made by decorators when they have used a varnish, say in a hall, and that one side of such hall is in quite good condition while the other has "bloomed" badly The explanation is that the front door was left open on a dull day while the varnishing was proceeding, and the draught struck one side of the wall and adversely affected the varnish.

To facilitate the drying of oil paints, driers (*q.v.*) are usually employed in a quantity depending upon the kind of pigment that is used in a paint. Thus, red lead requires no driers at all, it being in itself an excellent drier, or in other words, a pigment which rapidly absorbs oxygen. White lead is a partial drier and requires very little added material. Vandyke brown, the lakes and the blacks are very poor driers and require a considerable quantity. The warning may be repeated here that an excess of driers in a paint is most objectionable. Sometimes the paint will dry hard on the surface and afterward become permanently soft. In any case, the addition of an excess of driers will seriously affect the durability of the paint film.

Spirit varnishes dry or become hard merely by the evaporation of the alcohol or methylated spirits used in their manufacture; whitewash, lime white, and distemper dry by the evaporation of the water contained in them. The point must not be overlooked in the case of distemper that as it dries it becomes very much lighter, so that in distempering a room one must not judge of the ultimate effect of the appearance of the distemper when it is first applied, but wait until it becomes quite dry. Decorators when judging of the colour of distemper needed in a room, paint a little on

a piece of paper, hold it to the fire to dry when it becomes lighter, and then place it on the wall to judge the effect.

DRIERS.—There has, perhaps, been more controversy in the paint trade concerning driers than on any other subject connected with it. As a matter of fact, it is not too much to assert that three-fourths of the driers sold are of very inferior character and, being complex substances, there is no practical method of effecting an improvement. Speaking generally, driers may be divided into two classes. Paste, or patent driers, and liquid driers. The first class consists of a paste made of various drying agents such as manganese on a base of barytes, whiting, or in some cases, white lead. If an inert material is used as a base, it is added to prevent hardening of the driers in the keg. Such material is often present to the extent of from 80 to 90 per cent., in some cases even more. It will be seen, therefore, that a painter who uses an inferior paste drier is wilfully adulterating his paint, and while he would probably be horrified at the idea of using white lead containing 10 per cent. of barytes, does not hesitate to add that material to his paint in the form of paste driers. In other countries these driers are used to a very small extent, and in America they are not used at all. There is, however, a French drier in powdered form which is an excellent article of its kind, but is intended principally for mixing with zinc oxide.

Liquid driers are made from linseed oil to which is added various drying agents. The best grades may be used with perfect safety provided there is no excess. Decorators who have not used them may be considered to be rather afraid of them on account of their paint mixers being inclined to use too large a quantity. But this difficulty may be overcome by the master painter

himself adding the necessary quantity to the raw linseed oil before he gives the materials out for mixing the paint.

There can be but little doubt that to the excessive use of driers may be attributed many of the troubles which occur with painted work. Beyond a certain point the addition of driers will actually retard the drying. In other cases, where too large a quantity of driers has been added, the paint film will quickly dry on the surface and afterwards the whole of the paint film will be found to have become soft—a condition which exists permanently. It may be taken as a safe rule that too much driers "burns the life out of a paint," to use a convenient phrase of the craftsman.

CHAPTER VI

SERVICE TESTS OF PAINTS AND VARNISHES

HOWEVER well a paint, enamel or varnish is "designed" and made, and however bright the prospect of durability may be, the only real test as to how long it will last is that of exposing it to the weather. A paint which may last very well indeed in the pure air of the country may prove an utter failure if used on the seashore or in a town where smoky or chemical fumes abound. Every paint and varnish manufacturer subjects his goods as made to service tests, and paints or varnishes boards which are exposed for one, two or more years, careful note being made from time to time as to their condition. A well-known Wolverhampton firm produced some years ago an admirable paint which is probably made from an admixture of pigments with a suitable vehicle, and took the wise precaution before placing it on the market, of painting a number of panels with the new paint, and at the same time painting smaller boards with a white lead paint mixed in the usual and orthodox manner. These panels were arranged alternately in a large frame and exposed on the roof of their factory some three years. At the end of that time many of the lead panels were in a very bad condition, while the specimens of their new paints were almost invariably in a very good condition indeed, although somewhat dirty. It is not every manufacturer who will take this trouble, but, as already stated, all paint makers make service tests themselves.

In the United States of America these service tests have been made on a systematic plan for many years

past, and the results have been published from time to time by the Institute of Industrial Research, Washington, D.C. These reports have been collected in a book by Mr. Henry A. Gardner,[1] which is full of interesting information on the subject of paint testing in general. The tests covered a period of six years, and include tests of lithopone, paints for Portland cement surfaces, marine paints, paints for metal, fungi or painted surfaces, and much more useful information. The tests of lithopone gave rather curious results; some specimens darkened badly under exposure, while in others there was no change of colour at all. At the end of eighteen months it was found that in a mixture of lithopone and zinc oxide 40 per cent., sublimed white lead 30 per cent., and corroded white lead 20 per cent., all gave excellent results and there was no darkening after three months.

The tests of paints on metals make very interesting reading. Steel panels were coated, and photographs are given in the book named of the condition of the surface after a given period. The highest ratings, that is to say, the paints which stood highest when they had been examined by practical painters, were as follows in the order named: (1) Basic chromate of lead; (2) sublimed blue lead; (3) carbon black and barytes; (4) chrome green; (5) willow charcoal; (6) red lead; (7) natural graphite containing clay, etc.; (8) zinc chromate; (9) zinc and lead chromate; (10) magnetic black oxide. A large number of paints made from different pigments were made in addition, but they all fell below those named.

Tests of 100 white paints of different compositions used on wood were made, painting panels with various mixtures and exposing them for several years. The

[1] *Paint Researches and Their Practical Application*, by Henry A. Gardner (Press of Judd & Detweiler Inc., Washington, D.C.).

tests were made under the supervision of a Committee acting as representatives of the American Society for testing materials. Space will not permit of even a summary of the conclusions reached, but the results are worthy of note and they fully support the author's opinion that an admixture of pigments, when made on a scientific basis, exceed the durability of a single pigment. The Committee reported that none of the paints composed of a single primary pigment were equal to the paints made up with composite pigments, except zinc lead white, which is actually a composite pigment. In the groups where two or three different pigments were used those containing zinc oxide showed less cracking and checking, and whiter and cleaner surfaces than those groups in which it was absent. The condition at the date of report seems to warrant the statement that those in which four pigments were used were in the best condition of any of the panels included in the tests.

TESTS SHOULD BE MADE IN THIS COUNTRY.—It is, perhaps, not too much to hope that a series of paint tests may be made in this country, particularly now that we have a Government Department of Scientific and Industrial Research. Instead of arguing as to whether zinc oxide is better or worse than white lead, or whether an admixture of the two is better than either, what is wanted is to ascertain the actual facts by having boards of well-seasoned wood, steel and iron plates, and other surfaces painted with different admixtures and exposed in different parts of the country; such, for instance, as in London, Manchester, Birmingham, and Glasgow; at several points on the coast, north, south, east and west; in chemical manufacturing towns like Widnes and Runcorn, and also in the pure air of the country. It would be necessary to have the samples prepared under the

supervision of paint experts who would keep a careful record of the space covered by each paint, its exact composition both as to pigment, vehicle and drier, and a note as to the cost. The actual painting should be done by an expert "brush hand," *i.e.*, a practical painter. All the samples should be exposed at the same time, and they should be examined every six months by a local committee of practical painters who should report as to the condition of each sample. Thus it might be found that a paint would last very well for a year and then go to pieces, while another which showed signs of decay at the end of twelve months would be almost in the same condition after three years. It would be a boon also if the same thing could be done with varnishes and enamels.

The author took part in some service tests of this kind with varnish many years ago in connection with the National Association of Master House Painters and Decorators of the United States. In this case it was deemed necessary to purchase on the open market the varnishes which were put under test. This was done by the committee who soaked off the labels, numbered each one and put a corresponding number on the package. All the packages were then sent to a different committee altogether who were thus not acquainted with the name of the manufacturer. This committee got to work and varnished various surfaces such as grained work, plain painted work on flat, and on semi-flat boards. The boards were then exposed at such points as New York, Detroit, Michigan, St. Louis, Chicago, and other large towns, and after a year the whole of the specimens were brought to a Convention of Master Painters when a third committee was appointed to examine them and arrange them into grades according to their condition. Strange to say, there were only

two varnishes out of the whole lot which were deemed to be superior to the rest and graded as 1. A very large number came under Grade 2, and the remainder were ruled out as not being up to the mark. The grading having been completed the names of the manufacturers of the brands of each number were then disclosed.

It is suggested that something of the same kind might be done in this country. The essence of the success of the tests was that all the goods were purchased on the open market. Had the committee applied to the manufacturers for samples for testing purposes, it might have been urged that a special grade was made for the purpose. There would be little difficulty in carrying out such tests as those suggested. We have a National Federation of Master Decorators and House Painters; a Federation of Paint, Varnish and Colour Manufacturers; The Paint and Varnish Society; and The Society of Paint and Colour Chemists, all of them intensely interested. The test would certainly cost money, and if this could be provided by the Government Research Department the rest would be easy. Assuredly, the results obtained would be of very great service to architects, property owners and others, and would well repay the trouble and money expended.

CHAPTER VII

MACHINERY USED IN PAINT MAKING

SPACE will not permit of a lengthy description being given of the somewhat elaborate machinery which is used in the manufacture of paint. A few of the principal types, however, may be briefly referred to. Perhaps the

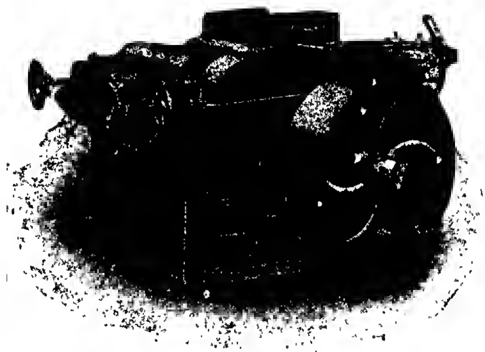


Fig. 2

GRANITE ROLLER MILL

most important machine is that which is employed to grind dry pigment with oil. For this purpose granite roller mills are usually employed. (Fig. 2.) These consist of two or more cylinders of granite mounted in such a manner that they have a lateral motion while revolving. In the old-fashioned machines of this type the rollers were geared in such a way that one of them moved faster than the other and this effected a grinding

action. The same plan is followed to-day with the addition of the lateral movement, and it is found that the actual grinding motion is greatly improved by this simple device. Some pigments are best dealt with

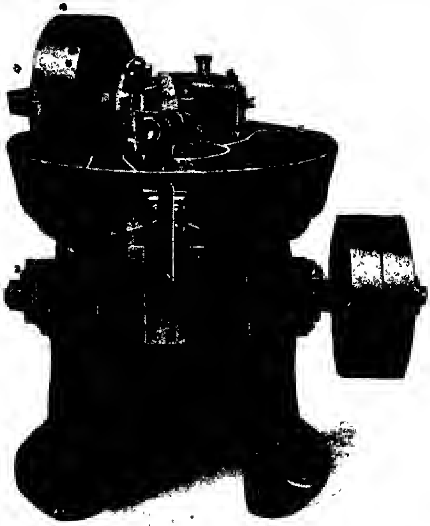


FIG. 3
SINGLE EDGE RUNNER

by means of what is known as the edge runner, an example of which is shown in Fig. 3. Such a machine is used in making putty. There is provided on the inside of the pan a scraper which throws the putty toward the centre of the pan. In this case the weight of the runners has much to do with the mixing or grinding action.

It may be noted that another machine which is used for making putty, and which is illustrated on page 45, was designed for mixing dough, but is found equally

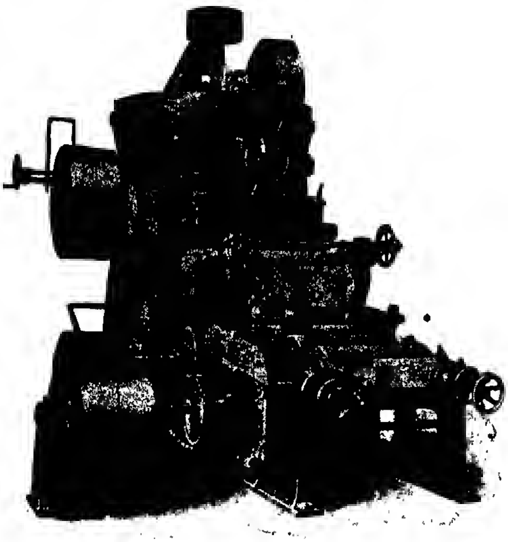


FIG. 4
TORRANCE'S COMBINATION PAINT MILL

serviceable for putty-making. The most perfect installation of a paint factory may be said to be Torrance's Combination, which is shown in Fig. 4. It is particularly serviceable for mixing and grinding white lead, zinc white and other paints or pastes in one operation, commencing with the lead or other materials in the dry state and finishing them in the same machine to a high state of

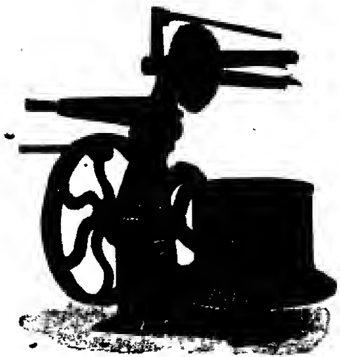


FIG. 5

THE LITTLE GIANT PAINT MIXER

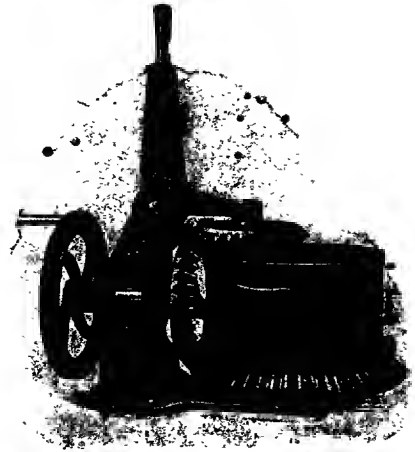


FIG. 6

THE WEE MACGREGOR PAINT-MIXER

fineness and perfection, ready for the market. The dry material and the oil are taken to an upper floor and the whole operation is completed with one machine with a great saving of labour. Briefly, the action is as follows: A

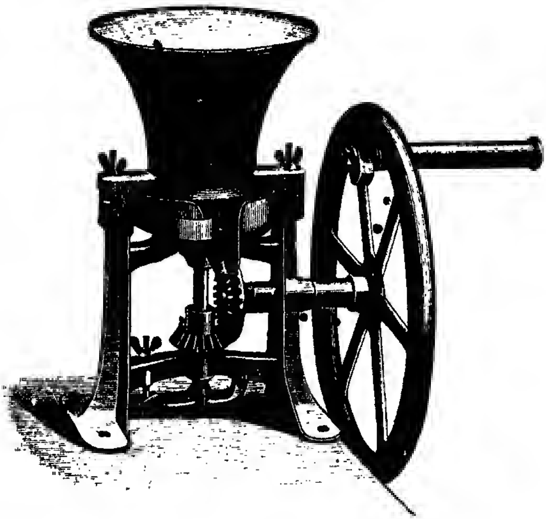


FIG. 7
PAINTER'S CONE MILL

charge of dry material and oil is delivered to the upper pan and when ready it is charged into the receiver which mechanically delivers it to the triple granite roller mills where it undergoes a complete final grinding. While this is proceeding the second charge can be introduced into the pan above. The operation is thus

continuous. It may be useful to mention that the 7-ft. size machine has an output of from seven to ten tons of finished lead a day.

PAINT MACHINERY.—The two illustrations in Figs. 5 and 6 show an excellent form of paint mixers which are

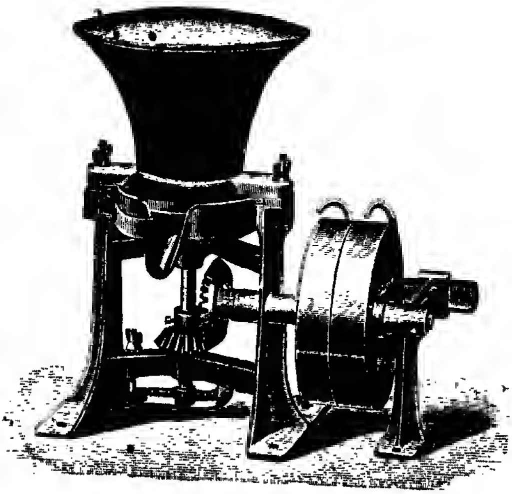


FIG. 8
CONE MILL (POWER)

operated by hand. They are called respectively the "Little Giant" and the "MacGregor." The capacity of the former is 5 gall. and of the latter 2½ gall. It will be observed that the construction permits of the mixing knives being lifted out of the paint container by means of a lever. This facilitates cleaning and is an exceedingly useful feature, where small quantities of

paint are to be mixed at a time. If desired pulleys can be added to work the machines by power.

Most painters have on hand a cone mill which is used for grinding superfluous paint, waste, etc., and also for reducing paints, such as white lead, etc., as may have become hardened. The illustration of a very good cone mill is shown in Fig. 7. It is provided with a hand wheel, machine-cut cones and has an enamelled cone and spout. The diameter of the cone is 6 in., and the capacity of the cone 7 pt. The approximate output in a day is from 1 to 2 cwt. The same mill is shown in Fig. 8 with pulleys and belt gear for power. These are made by Messrs. Torrance & Son, Bitton, Bristol.

FIG. 9
GARDNER'S SIFTING MACHINE

LEVIGATION. — Many pigments, particularly those of natural origin, have to be freed from gritty matter before they can be used as paint, or rather before they are ready to be ground to their final degree of fineness. With this object the process known as levigation is usually followed. The pigment having been broken up to the form of powder is introduced into the first of a series of tanks which are so arranged that water from one flows into that adjacent. With this object the height of each tank is a little greater, or less as the case may be, than that of the tank next to it. The material is placed in the first or highest tank with plenty of water. It is then stirred up very thoroughly and allowed to settle, when all the coarser and gritty parts sink to the bottom leaving the finer particles more or less in suspension. The top portion carrying with it the

Fig. 10
DISINTEGRATOR SHOWING CONSTRUCTION

suspended pigment is then run off to the second tank and allowed to settle as before, when the top part is run into a third tank, and so on, until a pigment of very finely-divided particles is obtained. This method is used with white, sienna, ochre, native Indian red, oxide of iron and many other pigments of the kind. Sometimes the deposit in the second, third or fourth tanks is run through a grinding machine, but much depends upon the nature of the pigment which is being dealt with. The material which comes from the last tank is made into cakes dried in stoves, and is then ready, if required, to be ground in oil.

The process of levigation can be carried on sufficiently in a special machine made for the purpose, and although such a machine costs a fair amount of money, it occupies but little room and may be regarded as being cheaper than constructing a series of settling tanks.

Messrs. Torrance & Son, Ltd., make a levigation mill of the kind referred to. It is 7 ft. in diameter, and is fitted with an improved bottom feeding arrangement by which the crude colours are fed directly under the runners, gravitation.

By such machines the sand and grit contained in crude oxides, ochres, etc., are removed. In this mill, the law of gravitation works throughout the different stages, so that the very smallest amount of labour is required to handle considerable quantities of colour, the delivery from one point to another being brought about by natural force.

Another machine, which may be mentioned in this connection although it is of an entirely different character, is shown in Fig. 9. This is used for sifting various dry powders and is very effective and expeditious. The construction may be thus briefly described. The sifting apparatus consists of specially made silk of very

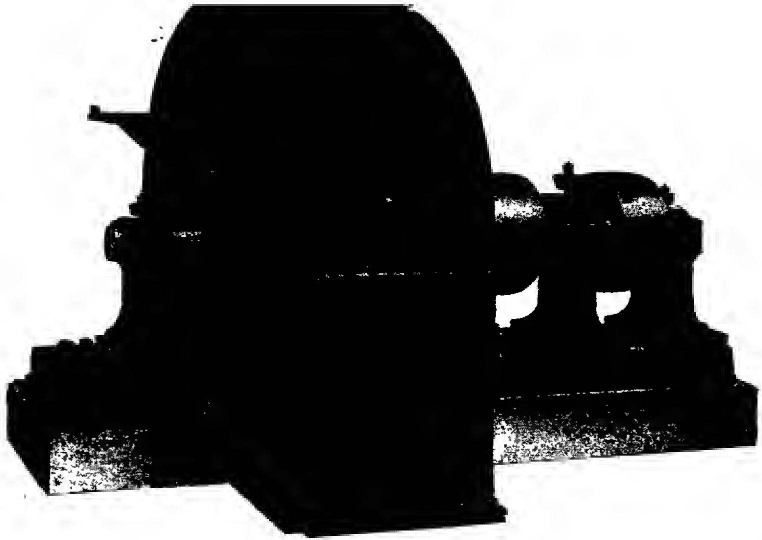


FIG. 11
DISINTEGRATOR

fine texture. The powder which, introduced into the apparatus, is forced by a series of revolving brushes against this silk which thus eliminates all the coarser particles. Pigments of exquisite fineness may be obtained by these means. The machine is made by Messrs. Gardner & Sons, Ltd., Gloucester.

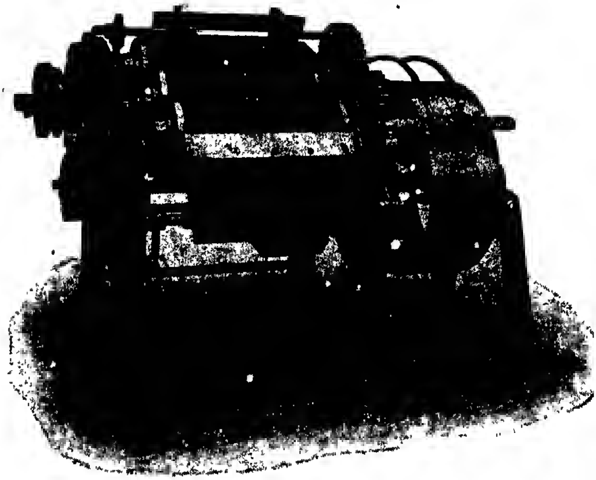


FIG. 12
THREE GRANITE ROLLER MILL

Turning from very fine to very coarse materials, mention should be made of disintegrators shown in Figs. 10 and 11. Sometimes metallic ores which form the base of good paints have to be reduced to powdered form. In such a case it is necessary to first reduce the rock to small pieces which are afterwards further reduced to a powdered form. These are made by

Messrs. Crone & Taylor, St. Helens. A form of Granite Roller Mill made by the same firm is shown in Fig. 12.

THE CHEMICAL ENGINEER.—Important as a knowledge of applied chemistry is in paint making, an intimate acquaintance with practical engineering is even more essential. Some of the principal types of machines employed for the different operations of grinding and mixing either dry or with water, turpentine, or oil have already been given. Their peculiar functions are utilized according to the particular pigment and medium which is being dealt with. Thus a heavy edge runner may be the type of machine chosen for making putty, or a stiff paste paint, while a granite roller mill may be used for grinding white lead; or, again, a water-cooled cone mill may be employed for white enamels, it being necessary in this case to keep down the heat which would spoil the colour.

All such points are well understood by the practical chemical engineer. It is, however, upon the economical arrangement of the whole paint factory that success will mostly depend. These operations are so varied, both in magnitude and kind, that economical production is only possible when the whole scheme of operations, and particularly the handling and transmission of the raw material, are fully considered and dealt with on a broad basis.

There is no doubt that not a few British paint factories fall lamentably short of the ideal in this respect. Some of them have existed for many years, and new plant has been added from time to time as necessity may have dictated. Only too frequently under such circumstances the plant is hopelessly inadequate from the economical point of view. In this industry, as in many others, there are many factories which it would pay the owners to scrap entirely, and the greatest blessing for

such owners would be a big fire which would destroy the lot and render rebuilding necessary on a scientific plan.

It is in the equipment of their factories that the Americans score so highly, and a story told of an American carpet manufacturer may be mentioned here as pointing a moral in this connection. Some years ago at Yonkers, New York, a new factory was erected with the very latest machinery and at a cost of many thousands of dollars. On the eve of opening, when everything was in complete working order, news was received that patents had been granted on certain mechanical improvements which had at that time not been contemplated. The proprietor of the new factory at once decided to scrap the whole of his new machinery before even a single yard of carpet had been made. This plucky action of course paid well in the end, as in a few years the whole of the primary loss was made good.

The following are some of the most important items connected with the arrangement of the plant in a paint works—

(1) Oil, turpentine and other liquids which form part of the paint, should be so located that they may be received with a minimum of labour, and be pumped to those parts of the works where they are required with the shortest possible length of pipe. It may here be remarked that in very extensive works it may be necessary to provide a series of tanks, one to receive the raw material as it is delivered, the next as a general store, and the third to be located in a situation comparatively close to the paint mills, so that the contents may be drawn off as required.

(2) In many operations of a paint factory the greatest advantage will be taken of gravity, so that the materials stored in upper floors may be conveyed to lower

situations without undue labour. In the manufacture of colours made by "striking," this arrangement of the various liquors is very essential.

(3) Where the extent of the works necessitates it dry material should be conveyed by worm conveyors, with or without the additional assistance of bank conveyors.

(4) As it is frequently necessary to mix quite small batches of some particular colour, or to work to given formula in small quantities, and at the same time and in the same general installation to produce much larger quantities it is desirable to arrange a system of "cut-off" in order that one machine or set of machines may be thrown out of working at any particular time required. With this object the simplest and most economical system is the adoption of small electric dynamos, working single machines or one or two of the smaller ones.

The conveyance of dry materials is one which is very frequently neglected, probably owing to the fact that it seems a simple matter to shovel up a quantity of such material and to convey it in barrows or carts from one part of the works to another. At the present time, however, when the cost of labour is so high, it will probably be found that a mechanical distribution of the raw material will be very much more economical in the end.

The advantages of mechanism in conveying dry powders is well illustrated in the dry soap trade. The manufacture of dry soap is a very simple matter, and consists merely of grinding together a quantity of soap (shredded and dried) with ordinary washing soda. This is usually done by means of an edge runner, which is located in the basement. The problem now is how best to convey the finished material to other parts of the works for packing. In most up-to-date factories this is done by small bucket elevators, which take the

powder up vertically and discharge it to any floor required. The actual discharge is made upon travelling bands which run at right angles, so that by cutting off or readjusting any part of the mechanism, the dry powder made at a single point in the basement may be conveyed to any floor in the building, and to any part of that floor, without being touched by hand. This is the explanation of why first class dry soaps were sold some years ago at prices which appeared to be ridiculously low. The explanation was the economy effected by the machinery. To a limited extent a similar saving could be effected in many branches of the paint trade.

CHAPTER VIII

VARNISHES AND ENAMELS

VARNISH has been defined as "any liquid not containing suspended matter (pigment) used for decoration or protection and capable of being spread in a thin homogeneous film which will dry to a hard coating."

According to A. H. Sabin, the oldest varnish in existence is that on the wooden dummy cases brought from Egypt; these are probably 2,500 years old. Varnishes may be divided into two classes, (1) oil varnishes which are by far the most important class and which are made from gum resins or their equivalents together with linseed and other oils and turpentine or benzine; and (2) spirit varnishes which are made from resin such as shellac and a volatile solvent, usually alcohol, in the form of methylated spirit.

Two little books in this series deal at length with two of the principal ingredients of oil varnishes, viz., *Oils: Animal, Vegetable, Essential and Mineral*, by C. Ainsworth Mitchell, B.A., F.I.C., and *Gums and Resins, There Occurence, Properties, and Uses*, by Ernest J. Parry B.Sc., F.I.C., F.C.S. We shall therefore confine our remarks in this book to the different grades of varnish and the purposes for which they are used.

Sabin divides varnishes into sixteen different classes. Although this number might be subdivided to almost any extent, yet the classification is a convenient one, while it indicates the many widely different purposes for which the materials are employed. The Murphy Varnish Co. claim that there are "two hundred varnishes for two hundred purposes." This Company says,

"Because all varnishes *look* alike people suppose they *are* alike, and that any varnish put on anyhow will do for any job. Varnish is varnish; yes, and medicine is medicine. You can go into a pharmacy where a hundred different medicines, the cures for a hundred diseases, all look alike—a hundred bottles of white pellets; take a few of them and if you're still alive, you'll know the difference. A few more than 200 different varnishes are made by this company. They all look very much alike; but each one is a problem by itself; fitted to accomplish a separate and exact result, as each white pellet is to cure a certain disease. The prices range from 5s. to 24s. a gallon, but the most expensive would not do certain kinds of work for which less costly grades are devised. A wealthy gentleman thought all varnishes were for all uses and that getting the best was simply paying the most. He could not find marine varnish that cost more than 16s. a gallon; so he paid a guinea for piano varnish, and put it on his motor-boat. Of course it went to pieces in a month, although it lasts twenty years or more on a piano. Piano varnish is not an outdoor varnish; especially it is not a salt-water varnish. There is '*best*' varnish only in the sense that there is best cloth. It depends on what you want the cloth for; business suit, hunting suit, or dress suit—August or January. It depends as completely on what you want the varnish for."

The division of varnishes into sixteen classes is as follows—[1]

(1) ARCHITECTURAL VARNISHES, for doors and floors and all other joinery, both inside and outside the building: and for special decorative work.

(2) BAKING VARNISHES, for art metal works, grills,

[1] *The Industrial and Artistic Technology of Paint and Varnish*, by A. H. Sabin, M.Sc. (Chapman & Hall).

partitions, etc., for sewing-machines and typewriters, and fine machinery.

(3) BLACK VARNISHES, for general iron work, machinery, implements, utensils, etc.

(4) CABINET VARNISHES, for cases, files, desks, fine tables and chairs, and for all the more elegant pieces of home and office furniture.

(5) CARRIAGE VARNISHES, for carriages, traps, coaches, etc., for bodies and for gears.

(6) CASKET VARNISHES, for caskets, and casket cases of various kinds, *i.e.*, coffins.

"COACH VARNISHES."—"Coach" is the most abused and the most confusing word in the business. Originally "coach varnish" meant a varnish for coaches, but the name has come to be applied almost universally to varnishes for house use, especially to furniture varnish—to some very poor furniture varnishes.

(7) FURNITURE VARNISHES, of many kinds and grades of furniture.

(8) IMPLEMENT VARNISHES, for all sorts of agricultural implements.

(9) LEATHER VARNISH, for carriages and motor-car tops.

(10) LINOLEUM VARNISH, for linoleum and oilcloth.

(11) MARINE VARNISHES, for steamships and steamboats, and motor-boats and yachts and canoes—for all craft; inside and outside work.

(12) MOTOR-CAR VARNISHES, for motor-cars of all grades; for wood and metal bodies, and for gears; for natural wood or over colours.

(13) PIANO VARNISHES, for pianos and organs in natural wood or colour; for their plain surfaces and for their legs and mouldings. Sounding-boards require a special kind.

(14) RAILWAY VARNISHES, for palace and passenger

and baggage cars, and for street cars—for all sorts of cars that are made of wood—inside and outside work—for floors and decorations and lettering.

(15) Steel Car Varnishes, for all kinds of cars that are made of steel, and for all parts of them; for locomotives and tanks.

(16) Wagon Varnishes, for delivery wagons, hospital wagons, farm wagons, trucks, etc.

The Manufacture of Oil Varnishes.—The process of making ordinary oil varnishes is not complicated, but it requires a considerable amount of experience. The first part of the process is to melt the gum resins, technically known as "gum running." For this purpose "gum pots" set in cylindrical holes, over a coke furnace, and on the level of the ground, are employed and the resins are introduced into these pots and are subjected to a heat which gradually rises to about 650° F. The pots are covered in at the top and are usually fitted with a pipe which conveys to a distant condenser the smoke and fumes which are given off during the operation. The gums are frequently stirred during the time they are melting by a light iron stirrer to which some of the melted gum adheres, enabling the experienced operator to judge accurately when the whole of the gum in the pot has become melted. It is important that no part should be left unmelted, and it is equally important that the process of melting be done as quickly as possible, because a considerable loss occurs by the giving off of inflammable vapours if the process is prolonged; indeed this loss takes place to some extent in any case.

Boiling the Oil.—During the time the gum is being melted pure linseed oil of the best quality is being heated in another pot or kettle and this is added to the melted gums in small quantities at a time. If the varnish is to be of the "long-oil" variety—*i.e.*, one which

is to contain a considerable quantity of oil in order to render it elastic—it will usually be necessary to return the pot to its position over the furnace before the whole of the oil is added. The oil is heated to a temperature depending upon the varnish and the kind of gums employed. From 212° F. to 500° F. may be taken as the extremes. Driers are often added to the oil but more usually at a later period, and constant stirring takes place during the time the oil is being added.

BOILING THE OIL AND GUMS.—The next operation is to boil or cook the mixture of oils and gums, and for this purpose the pots are placed back in their positions over the furnace and the cooking proceeded with. The length of time the boiling takes varies from, say, three-quarters of an hour to five hours. The temperature also varies, but is usually about 500° F. A thermometer is used to assist in keeping the heat to a pre-determined degree, but more frequently the fact of a complete amalgamation between oil and gum is ascertained by practical tests such as that of dropping a little on a piece of glass when a cloudy effect will be produced if the varnish is undercooked, or by observing whether it is "stringy," a condition which points to the same defect. When the boiling is completed, the pots are withdrawn from the fire and are wheeled to a distant place, such as a shed, to cool to about 300° F.

THINNING.—Pure American turpentine is now added in small quantities at a time, the mixture being constantly and vigorously stirred throughout the operation. The quantity of turpentine needed will depend upon how much oil has been used. The greater the quantity of oil the smaller the amount of turpentine will be needed.

It may be mentioned here that there is great danger of fire taking place during this process of thinning,

owing to a considerable portion of the turpentine being converted into a heavy vapour. Good ventilation of the room in which the thinning is done, together with the presence of plenty of sand to put the fire out should one occur, are essential for safety. The floor should be 6 in. or so lower than the outside pavement, so that if a fire does occur the lighted fluid will not flow out but will be confined to the building in which it originated. Piles of sand are used at the entrances with the same object and iron doors are usually provided as an additional precaution.

TURPENTINE SUBSTITUTES.—Of late years "white spirit," a petroleum product not unlike ordinary petroleum, has been successfully used in place of genuine American turpentine in the manufacture of oil varnishes and with considerable success. Careful investigation has shown that it may be used with perfect safety provided that the flash-point of the particular grade of the material is carefully regulated according to the purpose for which it is to be used (*see also* page 43).

THE MATURING OF OIL VARNISHES.—The last detail in connection with the manufacture of oil varnishes is to "age" it or allow it to mature. This is done by placing it in tanks and keeping it for from twelve months to two years in a uniform temperature, night and day, of about 60° F. to 70° F. During that time certain impurities settle to the bottom of the tank rendering the varnish above much clearer and brighter than the newly-made product. Some of the large railway companies, in order to ensure the varnish they buy being well matured, purchase a tank-full at the time and place their seal upon the tank drawing the material off, as it may be required, after a year or so.

As the maturing of varnish takes time and therefore

locks up capital, some attempt has been made to speed up the operation by extracting the foreign material by passing the varnish through filter processes.

ROSIN VARNISHES.—Formerly those varnishes which were made principally from rosin (colophony) instead of gum resins were regarded as being of a very low grade, but at the present time first-class varnishes may be made by using rosin in conjunction with "tung," or Chinese wood oil. The process, however, is too technical to describe here.

THE CLASSIFICATION OF VARNISHES.—Although we have in the above remarks divided up varnishes into two grades—oil and spirit varnishes, the former may, as already pointed out, be further subdivided according to the purpose for which they are to be used. As a rule, the varnishes which are to be used on exterior work will contain a considerable quantity of oil in their composition and will on that account be elastic. The following are a few grades of varnish which demand special mention.

RUBBING VARNISH.—This variety dries very hard, there being a relatively small amount of oil and much resin in their composition. They are used when two or more coats of varnish are to be applied in order to produce an extra brilliant finish, as in the case of carriages, front doors, etc. The rubbing down is done by means of powdered pumice-stone and water applied by means of a felt pad. This gives a very smooth surface to receive the finishing coat. Powdered cuttle-fish bone gives better results than the pumice. In the finish of tramcars, omnibuses, railway carriages, etc., the modern custom is to build up the surface in the usual manner with rough stuff but with fewer coats, and then to apply two coats of enamel of a suitable colour, each of which is rubbed down to a dull surface, and the work is

completed with a flowing coat of a good pale varnish. This varnish should contain at least 25 per cent. of oil as compared with the quantity of resin gums, and it should be very easy flowing and dry with a hard and very lustrous surface.

FLATTING VARNISHES.—These materials, as the name would suggest, yield a surface free from gloss. They were formerly made by the addition of a little wax and were far from durable. Modern methods, however, have produced flat varnishes which depend for their peculiar property upon the use of tung oil which in itself dries flat.

If a flat effect is desired on outside work, the best way to produce it is to use a good enamel upon a proper ground and to "flat it down," that is, rub the polish off with powdered pumice-stone and water. Of course, this is not the same thing as a flat varnish, because the pigment content of the enamel obscures the grain of the wood which the varnish would not do, but it is far more durable.

It is deemed advisable to include two or three typical examples of varnish recipes, although they will be useless to the general reader for practical purposes.

ELASTIC CARRIAGE VARNISH.[1]—Run 8 lb. of good quality copal, mix with 2½ gall. of oil, add ¼ lb. of anhydrous zinc sulphate and ¼ lb. of litharge; boil until it strings, then allow to cool and thin with 5½ gall. of turps. Run 8 lb. of second sort gum animi, mix with 2½ gall. of oil, add ¼ lb. of dried sugar of lead and ¼ lb. of litharge; boil until it strings, allow to cool and thin with 5½ gall. of turpentine. The two lots are mixed together, strained, and allowed to mature. This varnish

[1] From *A Manual of Painter's Colours, Oils and Varnishes*, by Geo H. Hurst, 5th Edition revised by Heaton and Blackler (Chas. Griffin & Co., Ltd.).

dries hard with a fine polish in five hours in summer, and in about seven hours in winter. It is used for finishing common carriages and also for cabinet work.

BLACK VARNISHES.—There are several different grades of these varnishes ranging from common Brunswick black to the best black japan. The former is used for ironwork and is made from asphaltum and coal-tar pitch, boiled oil and driers. These are boiled together, and when cool are thinned with turpentine. A better grade is made by using asphaltum without the coal-tar pitch. Black japan is made by melting asphaltum and then adding hot linseed oil and afterwards driers, such as red lead, copperas and litharge in considerable quantities, the mixture then being boiled and when cool thinned with turpentine.

GOLD SIZE.—This is a valuable drier which is also used by gilders to cause the gold to adhere to the surface to which it is applied. It is made in much the same manner as black japan just described, but the asphaltum is replaced by gum animi.

ENAMELS.—Ready-made enamels, which are now used to so enormous an extent, have only been produced during the last twenty-five or thirty years. Prior to that time high-class work was sometimes carried out by means of zinc oxide ground in oil and applied to a carefully-prepared surface. Sometimes there would be as many as eight or ten coats, the finish being done with two or more coats of very pale French or copal varnish.

The introduction of ready-prepared enamels changed these conditions entirely, and to-day a room can be enamelled perfectly with two coats provided that the ground is properly prepared.

Enamels are made in many different colours, but pure white or very light tints are the favourites both because

of their beauty and their remarkable durability. A first-class enamel will last almost indefinitely when used on an interior, and from five to ten years when exposed on outside work. At the end of that time the greater part of the gloss, however, will have disappeared.

The best white enamels are made from pure zinc oxide mixed with either a pale varnish or a specially-treated linseed oil or both. The cheaper grades often contain lithopone, but it is by no means so successful. White lead cannot be successfully used for making white enamels.

The following is a typical recipe for a white enamel intended to be used on outside work: 10 lb. of zinc oxide, ground in oil, are mixed very thoroughly with about 1 gall. of pale copal varnish; 1 pt. of pale japan gold size is added and the mixture is then thinned a little by the addition of ½ pt. of genuine American turpentine. It is of the utmost importance to extract every particle of material which could mar the uniformity of the enamelled surface and with that object the mixture is passed through a series of three sieves or strainers, the last being of a very fine mesh. The enamel being somewhat thick, soft revolving brushes are usually employed to facilitate the operation of straining.

Although the above recipe is a practical one, as a matter of fact "stand-oil" (which is a thickened linseed oil) often takes the place, either partly or as a whole, of the varnish, and excellent enamels are made which do not contain an ounce of gum resin.

As already intimated, the success of a job which is to be enamelled will depend to a very great extent upon how far the underground is rendered solid and smooth. The usual preparatory work will be done, including rubbing down, stopping, etc. Then at least two coats

of a good "undercoater should be given, each one being carefully rubbed down. These specialities are mostly made from lithopone (*q.v.*) which, as explained elsewhere, possesses unusually good "body" and spreading power; in fact more than any other pigment. For this purpose the material is ground with very little oil so that it dries flat or nearly so. Enamel shows up splendidly on such a surface, and if two coats are given —the first being rubbed down with pumice-stone and water—a perfect job is the result. In place of the undercoating white or tinted flat oil finish, such as "Vernasca," "Wallpax," "Matone," or "Indesco," may be used, and this is even better. White lead should never be used under white enamel, as it has a tendency to cause it to turn yellow.

Spirit Varnishes.—The most important spirit varnish is Shellac varnish, which is made by simply dissolving gum shellac in alcohol. Shellac varnish is largely used in America as an undercoat for oil varnishes. Knotting is really only a shellac varnish and is used, as the name would suggest, for applying over knots to prevent resin in the wood from exuding. It is also employed over sappy wood to yield a firm foundation. The proportion of shellac to spirit is about 3 lb. to the gallon. The shellac gum is dissolved in the spirit by agitation. The drums or barrels in which the material is made are mounted in such a way as to revolve and the same time to have a side-to-side motion by which means the shellac is driven from one to the other side of the barrel at quick intervals. A scraper inside the drum keeps the shellac from sticking.

French polish is also made in much the same way. It may be here observed that the practice of knotting as carried on by some painters is wrong. They are in the habit of taking a brush and very rapidly dabbing

over each knot with the shellac solution. The proper way is to take care to see that but a very thin coat of the shellac is given, as if it is thick it is very likely to show through the painted work, and if very thick it will sometimes crinkle and take a long time to dry. In any case, a thick coat of shellac requires a good deal of rubbing down. Two thin coats are very much more satisfactory.

McIntosh, in his standard work, on varnishes[1] gives the following recipes among many others—

FINEST PATENT KNOTTING.

Good (T.N.) Orange Shellac .	120 lb.
Methylated Spirit (64 o.p.) . .	24 gall.
Oxalic Acid	¾ lb.

The object of using the acid is to kill the natural dye contained in the shellac.

The following is a short list of additional spirit varnishes with a brief indication of their uses and the materials from which they are used.

Asphaltum spirit varnishes used as a "resist" in glass embossing and for etching and engraving on glass. Blackboard varnish for renovating blackboards; brown metal varnish, basket varnish, bookbinders' varnish, copal spirit varnish. Crystal varnish for wallpaper and (another variety) for photographic negatives; collodion or pyroxyline varnish, floor polish, furniture varnish, insulating copal varnish, leather varnishes, picture-frame varnish, retouching spirit varnish for photographers, straw hat varnish, wallpaper varnish and water varnish.

ENAMELS.—Enamels have been described as the cheapest paints it is possible to produce for outside use, and this remark is justified by the length of time they last. A really good enamel properly applied should

[1] *The Manufacture of Varnishes and Kindred Industries*, by John G. McIntosh (Scott, Greenwood & Son).

last unimpaired for at least seven years, and ten years would not be an excessive time. They are made in all sorts of colours, but white and light varieties are those which are most popular. Formerly enamels were made by mixing zinc oxide with certain pale varnishes, but in recent years the manufacture has undergone complete change. Most of the best enamels on the market have not an ounce of varnish in their composition. The material which takes its place is specially treated, or thickened with pure raw linseed oil, known when it was first introduced as "Stand oil." This produces a remarkably glossy effect, particularly when it is ground with zinc oxide which, it should be mentioned, is the only successful pigment that can be used in the preparation of first-class enamels. Lithopone is sometimes used for the purpose, but gives very inferior results. Enamels are made in two varieties, one intended for outside use, and the other for inside work, but the outside enamel is frequently used on interior work also. Forty years ago enamel work in the best drawing-room was a very formidable undertaking. As many as a dozen coats would be sometimes given and each one had to be very carefully rubbed down to a perfectly level surface. The finish was made with several coats of French oil or other very pale varnish. Nowadays, one may produce just as good a job with very much less work. In applying glossy enamel it is essential to obtain a perfectly level surface because the gloss will obviously accentuate any unevenness or inequality. If necessary, the work must be brought up level by using hard stopping which is a mixture of equal parts of white lead and ordinary putty. The surface is then well rubbed down and at least two coats of undercoating are then applied. These undercoats, it may be mentioned, are nearly all made from lithopone which possesses, as

already remarked, such splendid body and spreading qualities. It is not desirable to use white lead under white enamel as it has a tendency to turn such enamel yellow. Lithopone being a zinc paint, is free from this tendency. The last coat immediately under the enamel will be mixed without oil, or, at least, only the oil which has been used in grinding. This gives a flat surface to which the enamel will easily adhere. The work at this stage should present an appearance which is perfect in itself, that is to say, absolutely level and uniform, and one which the application of a coat of varnish would really give the same effect as the enamel, although the latter, containing a pigment, produces better results. The enamel should be applied freely, that is to say, should be regarded almost as a varnish. Some considerable skill is required in getting on the surface a maximum quantity of enamel without using sufficient to cause "runs." With this object the painter always takes care to finish his job, such as a door, by drawing his brush from the bottom in an upward direction to distribute any of the enamel which may have run down. A single coat of enamel is often regarded as sufficient, but in the very best work it is desirable to rub the surface down, preferably by means of powdered pumice-stone and water applied with a piece of felt, to a dull finish taking great care not to cut through the enamel, particularly on the mouldings and sharp edges. A final coat of enamel on such a surface will give what may be regarded as a perfect piece of work.

Flat Enamels.—"Flat Wall Paints" (*q.v.*) have, to a considerable extent, superseded flat enamels, but the latter are still used to some not inconsiderable extent because of their durability. The following recipes will be found useful for reference—

Grind 80 parts by weight of condensed French zinc

white, green seal, in a vehicle composed of 10 parts of varnish made from Kauri gum made of only 10 gall. of oil to 100 lb. of gum, three parts of palest lithograph varnish, 10 parts of pure turpentine. This will produce 100 lb. of soft paste base, let it stand for 48 hours, cover it with some turpentine to keep it from skinning over, then thin down with 24 lb. by weight of turpentine to the 100 lb. by weight of paste. By grinding calcined borax in varnish or pale oil and turps and adding as much as constitutes ½ lb. of dry borax to the above base, it will tend to make the material dead flat on drying. These flat enamels may be tinted to any desired effect with colours ground in oil, if only small proportions are required, otherwise the colours used should be ground in Japan and thinned with turpentine.

"Eggshell" Flat or Preparation for Enamel."

Oxide of zinc in oil	100
Linseed Oil	4
Turpentine	22
Driers	3

"True Flatting."

Oxide of Zinc in Oil	55
Oxide of Zinc in Turps	32
Linseed Oil	Nil
Turpentine	10
Driers	3

Note.—The use of oxide of zinc ground in turpentine as an ingredient of flatting is an important practical "wrinkle" well known to French and a few English painters. It is hardly possible to obtain a true "flat" with oxide of zinc except by this means.

The first of these recipes is reprinted from Uebele's *Paint Mixing and Colour Grinding*, and the last two from *Oxide of Zinc, Its Nature, Properties and Use* (Office of *The Decorator*).

SPREADING CAPACITY TABLE OF READY-MIXED PAINTS, UNDERCOATS, VARNISH AND ENAMELS.

From the Author's *Painters' Pocket Book*.

	Per gall.
Ready-Mixed Paints in Oil—	
First coat on wood or plaster . .	450 to 495 sq. ft.
Second coat on wood or plaster . .	540 „ 585 „
Finishing coat on wood or plaster .	675 „ 765 „
Ready-Mixed Paints in turps when used on an oil coat	765 „ 810 „
Undercoating ready for use—	
The ordinary "flatting type" . .	765 „ 810 „
The "flowing-out" type . . .	675 „ 720 „
"Paste" undercoatings to thin with turps 7 lb. require 1½ pt. turps covers . .	315 „ 360 „
Varnish (on a non-absorbent surface)—	
The easy-bodied type	810 „ 900 „
The full-bodied type	765 „ 810 „
Second cost 30 per cent. more.	
Enamel, Flat and Gloss—	
The easy-bodied type	675 „ 810 „
The full-bodied type	630 „ 675 „
Water Paints, Paste—	
7 lb. reduced on bare plaster . .	270 „ 315 „
The same figures to the finishing coat.	

NOTE.—The same figures may be applied to the finishing coat, because, although there is less suction, the material is used more "round."

SPREADING POWERS OF VARIOUS MATERIALS WHEN MIXED WITH OIL TO A WORKING CONSISTENCY.

(*Based on Hurst and Cruickshank Smith.*)

10 lb. of	Covers on Wood 1st Coat.	Covers on Wood 2nd Coat.	Covers on Metals.	Covers on sized Plastered Wall.
	sq. ft.	sq. ft.	sq. ft.	sq. ft.
Red Lead . .	112	252	477	324
White Lead . .	221	324	648	362
Oxide of Zinc .	378	453	1,134	504
Red Oxide of Iron .	453	540	870	
Raw Linseed Oil .	756	872	1,417	
Boiled Linseed Oil .	412	540	1,296	

RELATIVE COST OF PAINTS.
(*Cruickshank Smith.*)

	White Lead.	Oxide of Zinc.	Red Lead.	Red Oxide.
Covering capacity in sq. yd. per cwt.	806	1,411	594	1,083
Price per cwt. in shillings	32	36	32	28
Cost (in shillings) per 100 sq. ft.	0·44	0·28	0·60	0·28
Times painted in 20 years	5	5	3	7
Cost in shillings per 100 sq. ft. for 20 years	2·20	1·40	1·80	1·96
Relative economic value, the highest being represented by 100	64	100	77	71

COLOURS AND PIGMENTS, PERMANENT AND OTHERWISE
(*Based on Toch*)

All the following pigments are absolutely permanent, and can be mixed with each other (or used separately) without interacting upon each other. They are unaffected by light.

Alizarin Crimson
Alizarin Orange
Alizarin Scarlet
Alizarin Carmine
Asphaltum
Aureolin
Baryta White
Barytes
Bitumen
Black Lead
Blanc Fixe
Blue Black
Blue Verditer
Brilliant Ultramarine Blue
Blue Black
Bronze Green
Brown Lake
Brown Ochre
Burnt Roman Ochre
Burnt Sienna
Burnt Umber
Cadmium Yellow
Cadmium Orange
Cadmium Yellow (pale)
Caledonian Brown
Cappah Brown
Carmine in Oil
Cassel Earth
Cerulean Blue
Charcoal Black
Charcoal Grey
China Clay
Chinese Blue
Chinese Vermilion
Chinese White
Chrome Oxide
Chrome Red

COLOURS AND PIGMENTS—(contd.).

Cinnabar Greens, 1, 2 and 3
Cobalt Green
Cobalt Violet
Cobalt Yellow
Cologne Earth
Constant White (a)
Copal Megilp
Cork Black
Davey's Grey
Deep Madder
Extract of Vermilion
Field's Orange Vermilion
French Blue
French Ultramarine
French Vermilion
French Veronese Green
Foundation White
Gallstone
Geranium Lake
Geranium Madder
Gold Ochre
Graphite
Green Ultramarine
Green Lakes, 2 and 3
Gypsum
Indian Lake
Indian Purple (Oil)
Indian Purple (Water)
Indian Red
Ivory Black
Kaolin
King's Yellow (Oil)
King's Yellow (White)
Leitch's Blue
Light Red
Madder Carmine
Madder Carmine (extra)
Malachite Green
Manganese Violet
Mars Brown
Mars Orange
Mars Red
Mars Violet
Mars Yellow
Megilp
Mineral Gray
Mineral White
Miniun
Monochrome Tints (warm)
Monochrome Tints (cool)
Mummy
Naples Yellow, French
Naples Yellow, Greenish
Neutral Orange
Neutral Tint (Oil)
Neutral Tint (Water)
New Blue
Nottingham White
Olive Green (Water)
Orpiment
Oxford Ochre
Oxide of Chromium
Oxide of Chromium, Transparent
Payne's Gray (Water)
Permanent Blue
Permanent Green, Light
Permanent Green, Medium
Permanent Green, Deep
Permanent Violet
Permanent White
Permanent Yellow
Plumbago
Primrose Aureolin
Primrose Yellow
Prussian Brown
Prussian Green (Water)
Pure Scarlet
Purple Lake
Purple Madder
Raw Sienna
Raw Umber
Red Ochre
Rembrandt's Madder
Roman Ochre
Roman Sepia
Rose Lake
Ruben's Madder
Sap Green (Water)
Satin White
Scarlet Madder
Scarlet Red
Scarlet Vermilion
Sepia (Water)

Colours and Pigments—(*contd.*).

Spanish White
Strontian White
Sky Blue
Smalt
Terra-Alba
Terra-Rose
Terra-Verte
Transparent Gold Ochre
Tuscan Red
Ultramarine (Genuine)
Ultramarine Ash
Vandyke Madder
Venetian Red
Vermilion Pale
Verona Brown
Veronese Green
Viridian
Whiting
Warm Sepia
Yellow Ochre
Zinc Green
Zinc Oxide
Zinc White

Pigments which are absolutely permanent when used alone, but are not permanent when mixed with other colours—

Antwerp Blue
Cobalt Blue
Emerald Green
Flake White
Hooker's Green
Madder Lake
Ochre
Para Red
Paris Blue
Prussian Blue
Ultramarine (Artificial)
Vermilion

Pigments which dry slowly and irregularly—

Alizarin Yellow
Alizarin Green
Alumina White or Lake White
Bone Brown
Brown Madder
Brown Pink
Carbon Black
Carmine Lake
Crimson Lake
Crimson Madder
Gamboge
Indian Yellow
Lampblack
Magenta
Mauve
Orange Cadmium
Payne's Gray (Oil)
Rose Daree
Sap Green (Oil)
Scarlet Lake
Sepia (Oil)
Vandyke Brown
Violet Carmine
Yellow Lake

Pigments which are affected by sulphur gases and impure air—

Chrome Green
Chrome Orange
Chemnitz White
Emerald Green
Flake White
Lemon Yellow
Naples Yellow (Oil)
Naples Yellow (Light)
Naples Yellow (Medium)
Naples Yellow (Deep)
Naples Yellow (Reddish)
Silver White
Verdigris
White Lead

Pigments which are affected by light—

Brunswick Green
Gamboge
Lithopone
Orris White
Pink Madder
Rose Daree
Rose Madder
Sepia (Oil)

Pigments which may be regarded as being fugitive—

Bistre (Water)
Brown Pink
Burnt Carmine
Carmine in Water
Chrome Green
Citron Yellow
Crimson Lake
Dutch Pink
Indigo
Italian Pink
Magenta
Mauve Lake
Olive Green (Oil)
Prussian Green
Verdigris
Violet Carmen
Yellow Carmen

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APPENDIX

FIRE HAZARDS—THEIR POSSIBILITIES AND PREVENTION

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The purport of this chapter is briefly to set forth some of the possibilities of fire arising in works where the manufacture of colours, paint and varnish is carried on, how they may best be dealt with, and, what is really of more importance, how such fires may be prevented.

As has been indicated in the previous chapters (*see* pages 1 and 20), oil paints are made up of four parts: the base, to which is added the pigment, the vehicle (oil), the solvent (usually turpentine), and the driers (to hasten the process of oxidation). From this it will be seen that there are obvious fire hazards to be apprehended from the last three, whilst those from the " base " are rather more obscure. Each, however, will be dealt with in its proper course.

One of the principal causes of fires in works of this description is spontaneous combustion. This is substantiated by an analysis of 95 fires in paint works, from which it appears that 23 were attributed to this cause. The natural question follows: What is spontaneous combustion? A simple definition is: " Combustion produced without the application of heat from an external source."

This brings forth another inquiry: Why does such a phenomenon occur? Lavoisier discovered in 1743 that air is necessary for combustion. This was followed by the discovery that air was not an element, but composed

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chiefly of oxygen and nitrogen. He then established the fact that combustion was the evolution of energy during the rapid rushing together into combination of the combustible body and the oxygen of the air.

It has been mentioned earlier in this book that some oils have the property of drying more rapidly than others, and that if a powdered pigment be mixed with "boiled" linseed oil the paint so formed will harden and dry in a few hours, whilst if ordinary lamp oil be employed no drying action will take place. The drying of oils is due to the power which they possess of taking oxygen from the air and becoming converted into resins, the change from the liquid oil to the solid resin causing the hardening. This process, however, like all processes of oxidation, gives rise to heat, and although it escapes notice when it is taking place in the drying of paint spread over a considerable surface exposed to the air, it makes itself very manifest when the oil in a fine state of division is spread over the surface of such a non-conducting material as cotton, and it only needs a small quantity of such material to be collected in a heap for ignition to follow in a comparatively short space of time.

The following experiment can be cited as an illustration of this statement.

Some clean cotton waste was saturated with "boiled" linseed oil and placed in a stout paper box about 6 in. cube. The temperature at the time was 70° F. After 4½ hours the thermometer, which had been inserted in the waste, registered 80° F. After 5½ hours, 150° F.; after 6 hours, 420° F.; and after 6 hours 15 minutes, when the box was opened, the temperature was 440° F., and the cotton waste was charred entirely through.

The fundamental difference between vegetable or animal oils and the petroleum or coal-tar oils is found

in the fact that the former consist primarily of carbon, hydrogen and oxygen, whilst the latter do *not* contain oxygen, but are primarily compounds of carbon and hydrogen. This explains why the petroleum and coal-tar oils are free from the spontaneous combustion hazard.

It is remarkable that the drying quality of an oil is indicated by its iodine value, which corresponds with its ability to absorb oxygen. Iodine value can be defined as the amount of iodine chloride absorbed by 100 grm. of the substance expressed in terms of iodine. If the iodine value is high the oil will absorb oxygen readily, and it naturally follows that the more rapid the absorption of oxygen the greater the resulting increase in temperature and the more marked the spontaneous ignition hazard.

Having now dealt with the principal chemical or physical fire factor, it will be advisable to deal with each section of a comprehensive paint works as follows—

(1) The storage of pigments and materials.
(2) The manufacture of—
 (*a*) Dry colours
 (*b*) Paints
 (*c*) Varnishes (oil)
 (*d*) Enamels
 (*e*) Varnishes (spirit)
 (*f*) Cellulose paints, enamels and lacquers.

(1) THE STORAGE OF PIGMENTS AND MATERIALS

With the exception of the blacks, it may be said that practically all pigments are generally considered to be non-hazardous when in store.

As has been stated on page 27, black pigments are mostly produced by burning various materials. If the

resultant black is free from oil, not too closely packed, and preserved from dampness or heat, cases of spontaneous ignition will probably be rare. Although these blacks consist almost entirely of carbon, according to Dr. Wheeler in his report to the Home Office on the explosive properties of carbonaceous dusts, they are more or less readily inflammable, but show no signs of being capable of propagating flame and transmitting explosions when in a dust state and mixed with air.

Practically all the extenders and fillers are innocuous from a fire standpoint whilst in store, and no further reference is necessary, except that all dry materials, whether extenders, fillers or pigments, should be stored in substantial containers, and not in sacks or bags, the blacks being preferably in metal bins or canisters.

The oils mostly used are linseed (raw and "boiled") and tung oil.

Linseed oil is obtained from the seeds of the flax plant. It has a flash point of 512° F. and a boiling point of 662° F., whilst its iodine value is 187, the highest of any oil or ingredient used in paint making except turpentine.

"Boiled" oil is linseed oil that has been heated to about 350° F. (and consequently not actually boiled), and to which driers or oxygen carriers have been added.

Tung oil, also known as Chinese wood oil or Chinese nut oil, has a flash point of 552° F. and an iodine value of 175, thus indicating that its chief fire hazard (liability to produce spontaneous combustion) is almost as severe as that of linseed oil.

The thinners are primarily turpentine and turpentine substitute. The former is made from the gum or resin of fir trees. The flash point should not be below 90° F., and the boiling point 315° F., whilst the iodine value is 402. Turpentine substitute, usually called white spirit,

is really a petroleum spirit, and its flash point should never be below 75° F.; it being usually between 80° and 90° F. If it falls below 73° F. the liquid comes under the provisions of the Petroleum Act.

Such comparatively low flash-points indicate the necessity of no naked light being brought near either of these liquids.

The driers—full reference is made to these materials on pages 64 and 65. From their very nature it will be appreciated that they require attention from the fire hazard viewpoint, and in order to prevent trouble they must not be allowed to come into contact with oils or, in fact, any other materials indiscriminately. The chief likelihood of other dangers arising occurs in their manufacture, and care must be taken not to store them until they are really cold.

Lime is sometimes used, the fire hazard of which is too well known to require any emphasis.

A small amount of liquids with even a lower flash-point than the turpentine substitute is generally to be found in paint works, and the fire hazard therefrom is too obvious to necessitate any detailed description beyond mentioning the low temperatures at which such liquids ignite and boil, and the readiness with which the vapours they give off at such low temperatures combine with the oxygen of the atmosphere to form explosive mixtures ready to be ignited by the least spark or flame.

(2) THE MANUFACTURING PROCESSES

(a) Dry Colours.—These may be obtained direct from the natural earths or by precipitation and levigation therefrom, the two last methods naturally involving a considerable amount of drying, from which an appreciable fire hazard arises, and as it is obvious that ordinary

care should be taken in this connection to prevent a fire arising, nothing further need be said, except to indicate that owing to the mixing of certain chemicals to produce particular colours some chemical action may be set up which may be intensified by drying, thus producing fire trouble. Similarly, another fire hazard is induced in the grinding processes, and a few of the colours may possibly be ignited by the friction of grinding, even without a spark.

Colours produced by chemical action are usually prepared at works distinct from those making paints, and do not come within the scope of this book. In paint works such pigments are, as a rule, only blended or mixed together or with other pigments to obtain other colours.

Although, as has been mentioned, the blacks in their dust state when in suspension in the air do not form an explosive mixture, yet they and some of the other pigments, more especially those produced by chemical means, when in the fine state of powder to which they are reduced for use in making paint, act as ready fuel in the event of a fire, and consequently add their quota to the fire risk in these works.

(*b*) Paints.—It will have been appreciated from what has been said earlier in this chapter, and from the description of the process of paint-making as detailed in the main portion of this book, that the chief fire hazards have already been indicated, viz., grinding, which is usually performed in linseed or some other drying oil, and the concomitant danger of spontaneous combustion.

(*c*) Varnishes (Oil).—From the detailed description of the manufacturing process as given on page 90 and following pages, most of the resultant fire hazards will be realized.

The principal hazards in the gum-running and

subsequent processes are the ignition of the vapours, "boiling over" and overheating.

If adequate ventilation and draught is provided, as is usually the case in all well-designed factories, the ignition of the vapours should be a comparatively rare occurrence.

The gums and the mixtures of gum and oil are liable to foam and "boil over." As in certain other materials, the presence of water seriously increases this danger, and so every means should be taken to prevent its coming into contact with the oil. It must be remembered that if the gums or the mixture are heated unduly, that is to say, to a high temperature but less even than that necessary to cause a "boil over," the product is more or less spoilt. Consequently, these processes are watched incessantly and most carefully, thermometers and/or recording pyrometers being always used to assist in ensuring that the correct temperature is not exceeded. After the resultant mixture of oil and resin has been subjected to sufficient heat it is removed from the fire to cool, but whilst quite hot the thinners—turpentine, white spirit, or other volatile liquid—are added; this, too, is a somewhat hazardous process, but usually the arrangements are such that no fires arise therefrom. If filter cloths are used subsequent to the "boiling" they should be carefully looked after to avoid any risk of spontaneous combustion. If they cannot be thoroughly cleaned they should be burnt.

(*d*) ENAMELS.—On pages 95, 96 and 98, etc., will be found a description of the manufacture of enamel as undertaken at a paint works. It will also be seen that such enamel can be said to consist of pigments, etc., ground in oil varnish, in contradistinction to pigments ground in oil in the paint-making department. Such being the case it will be appreciated that the fire hazards are similar to those previously mentioned.

(*e*) VARNISHES (SPIRITS).—The manufacture of this class of goods is described on pages 97 and 98. It will be seen that the process involves the use of large quantities of volatile solvents, methylated spirits predominating. The flash-point of methylated spirits can be said to be approximately 55°–60° F., according to the denaturant used. Such a low flash-point constitutes a considerable fire hazard, but, fortunately, the process of making spirit varnish is a cold one. Nevertheless, particular precautions must be taken to prevent the vapour arising therefrom coming into contact with any flame or spark.

(*f*) CELLULOSE PAINTS, ENAMELS AND LACQUERS.—These consist primarily of celluloid dissolved in a volatile solvent which, when the paint, etc., is applied, generally by spraying, evaporates, leaving a very thin coating of celluloid upon the surface of the article painted.

The celluloid can be prepared from either nitro-cellulose (a species of gun cotton) or acetyl cellulose (or cellulose acetate), which in itself is non-inflammable, but which requires the same or similar highly inflammable solvents and diluents. These solvents and diluents are frequently amyl and butyl acetates, butyl alcohol, benzol, petrol, industrial spirit, etc.

These liquids have exceedingly low flash-points, some as low as 25° F. below freezing point, and the vapours from all form explosive mixtures with air. The majority, too, of these vapours are heavier than air, and consequently particular care must be exercised to see that there is no possibility of such vapours coming into contact with an open light or fire, or anything that can produce a spark, such as the electrical equipment, if not specially designed and arranged. The residue usually found on the bench or around the article that has been painted is liable to fire spontaneously if

subjected to any heat, whilst, if in dust form, such as would be produced by a scraper or cleaning knife, it can be ignited by a spark. Consequently, such cleaning utensil should be of non-ferrous metal or of stiff fibre.

Having dealt with the fire hazards arising from the various processes, it will be seen that the majority can be greatly minimized by the exercise on the part of the manufacturer of strict attention to—

1. *Cleanliness*, which is absolutely essential to prevent spontaneous combustion; and all waste material (particularly greasy cotton waste, paint scraping, etc.) should be put at once in metal bins, which should have legs and be fitted with lids, and removed outside the buildings or burnt daily. The entire works, too, should be regularly and frequently thoroughly cleaned.

2. *Commonsense.* This should be manifested in many directions, but particularly by exercising especial care that the old adage does not become applicable, viz., "Familiarity breeds contempt." Employees working daily with such volatile liquids will have a tendency to forget their danger, so that this will have to be frequently brought to their notice. Fortunately, there are a number of manufacturers who are keenly alive to the fire risks in this kind of work and who, in consequence, take every precaution to see that such an untoward occurrence as a fire arising from any cause is as remote as it can possibly be made.

Nothing has been said as to what are known as "common fire hazards,"[1] that is, fire hazards that are to be found in practically every industry. These all apply with considerable force in works of this description, particularly the following—

(*a*) Buildings in which any portion is of "defective

[1] See *The Common Hazards of Fire Insurance*, by W. G. Kubler Ridley, published by Sir Isaac Pitman & Sons, Ltd.

construction." All such portions should be rebuilt with incombustible material as soon as opportunity offers.

(*b*) Lighting. As far as possible only incandescent electric light should be used, and every part of every installation should strictly comply with the regulations of the Institution of Electrical Engineers.

(*c*) Unsatisfactory methods of heating, involving open fires and pipe stoves should be eliminated.

As regards *extinguishing fires* that may occur, it will be realized that in many cases the use of water would be worse than useless, as if oil or any volatile liquid were alight the fire might be spread by the burning oil, etc., floating on the water that was being used in the endeavour to extinguish the fire. Further, much of the stock of colours would be seriously damaged by the indiscriminate use of water, the colours not only being washed out, but mixed. In some fires the use of an inert substance, such as powdered barytes, of which there is generally a large quantity on hand, would probably be of great service in smothering a fire, whilst, in others, chemical fire extinguishers of the "foam" type would prove effectual.

A system of an adequate installation of automatic fire alarms should prove of considerable service by giving early notification of any rise in temperature, when the cause could be traced and remedied.

In conclusion, it may be said, risking the charge of reiteration, that undoubtedly the greatest safeguard against fire in a paint works is the maintenance of strict cleanliness and good management.